

## **ALGORITHMIC TRADING STRATEGIES**

Automating and Back-testing the Perfect Order  
Strategy

Otávio Silva Pereira

Dissertation presented as partial requirement for obtaining  
the Master's Degree in Statistics and Information  
Management

**NOVA Information Management School**  
**Instituto Superior de Estatística e Gestão de Informação**  
Universidade Nova de Lisboa

# **ALGORITHMIC TRADING STRATEGIES: AUTOMATING AND BACK- TESTING THE PERFECT ORDER STRATEGY**

by

Otávio Silva Pereira

Dissertation presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Information Management

**Supervisor:** Prof. Dr. Jorge Miguel Ventura Bravo

November 2021

## ACKNOWLEDGEMENTS

To my father and mother, Wellington Geraldo Lima Pereira (*In Memoriam*), Maria Lúcia Silva Pereira, who taught me the values of work, honesty, and ethics.

To my beloved wife, Marija Mihajlovic Pereira, and my dear children Danilo and Marko, who, without them, life would be meaningless.

To my thesis adviser, Dr. Jorge Miguel Ventura Bravo, for his patience, time, and energy spent with me. The completion of this study could not have been possible without his expertise and support.

To my professors and colleagues for sharing their knowledge and experience.

To NOVA Information Management School staff and board of directors, who provided the structure and conditions for completion of this work.

Finally, to my closest friends for their encouragement and support.

## **ABSTRACT**

The evolution of technology alongside the development of new techniques of algorithmic trading over the past 30 decades (Narang, 2009) allowed global financial markets to achieve higher transaction volume and execution efficiency (Kissell, 2006). In this context, those who fail to adapt to this reality may not survive in financial markets in the future (Chan, 2009). For that, as an attempt to participate in the ongoing automated trading evolution, the present study aims to back-test the Perfect Order Strategy (Lien, 2015) in some selected FX pairs through a fully automated trading system. As a part of the methodology process, the author developed the referred automated trading system through the use of different algorithmic techniques, trading, and risk management models available in the literature, see (Basso, 2019; Leshik & Cralle, 2011; Narang, 2009; Neely et al., 2014; Wilder Jr., 1978). Although the strategy had a positive return at the end of the tests, it performed below the S&P500 index over the same period. Moreover, the results from the back-test showed that the strategy was able to identify trends in its early stages reasonably. In turn, the automated trading system and the advantages that an algorithm execution-based system brought to the strategy played an important role in controlling losses and, therefore, protecting the investment capital. However, the procedures for establishing the stop-loss limit order and the take-profit target showed a flaw and were responsible, in part, for the poor performance of the strategy. Indeed, we are confident that further research in general, particularly in the stop-loss and take-profit target procedures, could improve the strategy's overall performance.

## **KEYWORDS**

Algorithmic Trading Strategies; Foreign Exchange Markets; Automated Trading Systems; Quantitative Trading

# INDEX

1. Introduction .....	1
2. Literature review .....	3
2.1. Algorithms and Algorithmic Trading Strategies .....	3
The benefit of deep thought.....	4
The measurement and Mismeasurement of Risk.....	4
Disciplined Implementation.....	4
2.2. Algorithms and the financial markets .....	4
2.3. Understanding a basic structure of an Algorithmic trading system .....	5
2.3.1. Alpha Models.....	6
2.3.2. Risk Models.....	10
2.3.3. Transaction Cost Models .....	11
2.3.4. Portfolio Construction Models .....	12
2.4. Foreign Exchange Markets .....	12
2.5. Position Sizing and Risk Allocation .....	13
2.6. Technical Indicators.....	14
2.6.1. Moving Average Indicator .....	14
2.6.2. Average Directional Index Indicator.....	14
3. Methodology .....	16
3.1. Hardware, Software, and the Programming Language.....	16
3.2. The Data and the Assets .....	16
3.3. The Automated Trading System .....	17
3.3.1. The Alpha Model Algorithm .....	18
3.3.2. The Risk Model Algorithm .....	22
3.3.3. The Execution Model Algorithm.....	25
3.3.4. The Position Management Algorithm .....	26
3.4. The Back-Testing.....	26
4. Results and Discussion.....	28
4.1. Back-Testing GBP/USD .....	28
4.2. Back-Testing EUR/USD .....	34
4.3. Back-testing AUD/USD .....	39
4.4. Back-Testing NZD/USD .....	45
4.5. Back-Testing USD/CHF.....	50
4.6. Back-Testing USD/CAD .....	55

4.7. Back-Testing USD/JPY .....	60
4.8. Summary Of Empirical Results Discussion.....	65
5. Conclusions, study limitations, and future research .....	68
REFERENCES .....	69
Appendix A – GBP/USD Back-testing Execution Log .....	72
Annex I – The automated trade system algorithm .....	83

## LIST OF FIGURES

Figure 2.4.1– Basic Structure of an Algorithmic Trading System .....	5
Figure 2.4.2– A Taxonomy of Theory-Driven Alpha Models .....	7
Figure 2.3.3– GBPUSD Daily Chart with Moving Averages (MA 50 & MA 200) Indicator.....	8
Figure 2.4.4– Taxonomy of Theory-Driven Models.....	10
Figure 2.6.1 – The trade Tripod .....	13
Figure 3.3.1 – The Automated Trading System Diagram .....	18
Figure 3.3.2 – Perfect Order Strategy Buy Model Sample .....	19
Figure 3.3.3 – Perfect Order Strategy Sell Model Sample.....	20
Figure 3.3.4 – Signal Conditions 1 and 2 .....	20
Figure 3.3.5 – Signal Confirmation Vector .....	20
Figure 3.3.6 – Alpha Model Algorithm (lines 133 to 146) .....	21
Figure 3.3.7 – Alpha Model Algorithm (lines 148 to 164) .....	22
Figure 3.3.8 – Check for Open Positions .....	23
Figure 3.3.9 – Setting the Stop-loss Limit price for a long position algorithm .....	23
Figure 3.3.10 – Trade lot-sizing algorithm for a long position algorithm .....	25
Figure 3.3.11 – Execution Model for a Buy Order Algorithm.....	25
Figure 3.3.12 – Position Management Algorithm .....	26
Figure 3.4.1 – Strategy Tester Settings for USD/CHF Back-testing .....	27
Figure 4.1.1– GBP/USD Range between Stop-loss Prices and Entry Prices of Rejected Signals .....	30
Figure 4.1.2 – GBP/USD Position Information (in pips).....	31
Figure 4.1.3 – GBP/USD Absolute and Maximum Drawdown Balances .....	32
Figure 4.2.1– Distribution of EUR/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades.....	35
Figure 4.2.2 – EUR/USD Position Information (in pips).....	36
Figure 4.3.1 – AUD/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades.....	41
Figure 4.3.2 – AUD/USD Position Information (in pips).....	42
Figure 4.3.3– AUD/USD Balance and Equity Evolution .....	43
Figure 4.4.1 – NZD/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades.....	47
Figure 4.4.2– NZD/USD Position Information (in pips) .....	48
Figure 4.4.3– NZD/USD Balance and Equity Evolution.....	48

Figure 4.5.1– USD/CHF Distance between Stop-loss Prices and Entry Prices of Rejected Trades.....	52
Figure 4.5.2 – USD/CHF Position Information (in pips).....	53
Figure 4.6.1 – USD/CAD Distance between Stop-loss Prices and Entry Prices of Rejected Trades.....	56
Figure 4.6.2 – USD/CAD Position Information (in pips) .....	57
Figure 4.7.1 – USD/JPY Distance between Stop-loss Prices and Entry Prices of Rejected Trades.....	61
Figure 4.7.2 – USD/JPY Position Information (in pips).....	62
Figure 4.7.3 – USD/JPY Balance and Equity Evolution .....	63



## LIST OF TABLES

Table 4.1.1 – GBP/USD Signals emitted by the Alpha Model .....	29
Table 4.1.2 – GBP/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades.....	30
Table 4.1.3 – GBP/USD Position Reward-Risk ratio (in pips) .....	31
Table 4.1.4 – GBP/USD Transactions Report.....	34
Table 4.2.1 – EUR/USD Signals Triggered by the Alpha Model.....	35
Table 4.2.2 – EUR/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades.....	35
Table 4.2.3 – EUR/USD Position Risk-Reward ratio (in pips) .....	36
Table 4.2.4 – EUR/USD Transactions Report.....	39
Table 4.3.1– AUD/USD Signals Triggered by the Alpha Model .....	40
Table 4.3.2– AUD/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades .....	40
Table 4.3.3– AUD/USD Position Risk-Reward ratio (in pips).....	41
Table 4.3.4– AUD/USD Transactions Report.....	44
Table 4.4.1– NZD/USD Signals Triggered by the Alpha Model .....	45
Table 4.4.2– NZD/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades .....	46
Table 4.4.3 – NZD/USD Position Reward-risk ratio (in pips) .....	47
Table 4.4.4 – NZD/USD Transactions Report .....	50
Table 4.5.1 – USD/CHF Signals Triggered by the Alpha Model .....	51
Table 4.5.2 – USD/CHF Distance between Stop-loss Prices and Entry Prices of Rejected Trades.....	51
Table 4.5.3 – USD/CHF Position Risk-Reward ratio (in pips).....	52
Table 4.5.4 – USD/CHF Transactions Report .....	55
Table 4.6.1 – USD/CAD Signals Triggered by the Model.....	56
Table 4.6.2 – USD/CAD Distance between Stop-loss Prices and Entry Prices of Rejected Trades.....	56
Table 4.6.3 – USD/CAD Position Risk-Reward ratio (in pips) .....	57
Table 4.6.4 – USD/CAD Transactions Report .....	60
Table 4.7.1 – USD/JPY Signals Triggered by the Alpha Model .....	60
Table 4.7.2 – USD/JPY Distance between Stop-loss Prices and Entry Prices of Rejected Trades .....	61
Table 4.7.3 – USD/JPY Position Risk-Reward ratio (in pips).....	62

Table 4.7.4 – USD/JPY Transactions Report .....	65
Table 4.8.1 – All pairs back-testing summary results.....	66

# 1. INTRODUCTION

Algorithmic trading, in today's global financial markets era, is paramount to investment strategies for achieving financial targets (Johnson, 2010). The use of algorithms by traders, investment banks, investment funds, and other players in the financial world to improve and execute, total or in some part, their trading strategies exists for more than three decades (Narang, 2009). Although it is difficult to confirm the exact participation of algorithms in daily trading volumes in financial markets, is evident that its use is growing at an outstanding pace since the mid-1990s (Leshik & Cralle, 2011).

The evolution of technology alongside the development of new methods of algorithmic trading allowed financial markets to achieve higher transaction volume, execution efficiency of a trade by lowering trading costs, improving portfolio performance, and providing better transparency (Kissell, 2006). The Bank for International Settlement (2019), in its *"Triennial Central Bank Survey: Foreign exchange turnover in April 2019 report,"* reveals that foreign exchange markets alone reached an outstanding turnover of US\$6.6 trillion per day in April 2019 (up from US\$ 5.1 trillion in 2016).

In this context, those who fail or take too long to adapt to this reality may find themselves in a very difficult situation and may not be able to survive in financial markets in the future (Narang, 2009). Inevitably, the ordinary individual retail traders, that lack financial and technical resources limitations when compared with investment banks, investment funds, and others big financial market players, are the ones in the most vulnerable position in financial markets. These traders may be the first investors to fail to survive in financial markets because they may not be able to adapt to the ongoing automated trading evolution (Chan, 2009b)

The main objective of this work is to back-test the Perfect Order Strategy (Lien, 2015) through a fully automated trading system the author of this thesis developed exclusively for this research to identify its strength and weakness. Moreover, using data collected from the back-testing, we look at the overall results of the strategy, at the same time that we go over the algorithmic structure of the automated trading system where the Strategy was inserted to point to problematic rules of the strategy for future research.

The Perfect Order is a theory-based strategy that seeks to identify a trending environment in its early stage by using price data as inputs. The strategy makes use of a set of six technical trending indicators to generate an entry signal: five moving averages (MA) in different periods – 10, 20, 50, 100, 200, and an average directional index indicator (ADX). A potential bullish trend is identified if the different moving averages align upwards; if the MA aligns downwards, a potential bearish trend is identified. Moreover, the ADX current value must be equal to or higher than 20. A signal is triggered if, and only if, the condition is maintained for five consecutive daily bars (Lien, 2015). The complete explanation of the strategy is detailed in Chapter 3 – Methodology of this work

An essential advantage of trend-based strategies is that, by following the trend, the trader is trading in the direction of the market. Thus, trend trading has an inherent rationale because trading in the same market direction makes sense. Thus, when done correctly, profits derived from winning trades can exceed the losses by a considerable amount. (Burns, 2014). Notwithstanding these optimistic characteristics, Burns (2014) continues, some estimates that markets trend approximately 20 percent of the time, making it difficult to determine the trend when a trader engages the markets and the probability that the trend will continue after the position is open.

From the above, we understood that the Perfect Order Strategy met the requirements necessary to be the core strategy of our fully automated trading system and was worth our time and energy to be the topic of our research.

This paper is organized as follows. In Chapter 2, we provide a literature review of the studies on algorithmic trading strategies and automated trading system theory that are related to the current paper. In section 3, we demonstrate the methodology used to construct the algorithm of the automated trading system and the execution and analysis of the back-testing of the strategy. In section 4, we provide mainly the results from back-testing of the Perfect Order Strategy for the selected FX pairs. First, we outline the signals the Alpha model emitted and look at the reasons the risk model rejected some of them. Second, we point to the profit or loss in relation to the risk the automated trading system took in each trade. Finally, we go through several financial metrics and assess the result of the strategy. In Chapter 5 we conclude our analysis and, finally, make suggestions for future research to improve the Perfect Order Strategy in Chapter 6.

## **2. LITERATURE REVIEW**

The present chapter provides the theoretical basis of this work, including a revision of the literature on the variables of interest. In the first part, we understand an algorithm and algorithmic trading strategies. We examine the importance of the benefit of deep thought for developing and implementing an automated trading system and identifying and treating risks that could put the automated system in jeopardy. We also review the relationship between algorithms and the financial markets, how their use and development over the decades grew among institutional financial institutions that directly impacted the daily volume transactions and operation costs.

In the second part, the core of our literature review, we dive into the basic structure of an automated trading system. We review the models that construct the system, such as the alpha model, which receives the trading strategy algorithm and where the research process is focused, the risk model, that access the risk of the trade and gives the permission to the execution model to fill up the order and sent it to the broker. Moreover, we examine the foreign exchange markets, looking at its daily transaction volume and its basket of major currencies. Finally, we look at some position sizing and risk allocation techniques, the Moving Average indicator, and the Directional Index Indicator, necessary to execute the trading strategy used in this research.

### **2.1. ALGORITHMS AND ALGORITHMIC TRADING STRATEGIES**

An algorithm is any well-defined computational procedure that takes values as an input and produces values as output (Cormen et al., 2009). In short, an algorithm is a set of instructions written by someone for accomplishing a given task (Johnson, 2010). Cormen et al. (2009) compares algorithms with computer hardware in a way that they believe algorithms are technologies. The authors continue stating that total system performance depends on choosing efficient algorithms as much as on choosing fast hardware. Algorithms are at the core of most technologies used in contemporary computers and quantitative trading is no different (Narang, 2009).

Algorithmic trading strategies are any form of trading in financial instruments using algorithms to automate all or some part of the trade cycle (Treleaven et al., 2013). Although automatization of trading takes place with limited or no human intervention (European Central Bank, 2019), the development of trading algorithms usually involves learning, dynamics, planning, reasoning, and decision (Treleaven et al., 2013). Furthermore, Narang (2009), in his book "Inside The black box, the simple truth about quantitative trading, "... defines algorithmic trading strategies as a product of systematic implementation of trading strategies created by rigorous research (Narang, 2009, pp. xi).

The financial markets, in general, are pacified that the implementation of automated trading systems brings benefits and advantages compared with manual trading. The European Central Bank, in an article released in early 2019, acknowledged that algorithmic trading facilitates the trading process by reducing labor and other related costs. Thus, that the automatization of trading permits large volumes of data to be analyzed in very short time frames (European Central Bank, 2019).

Narang (2009) agrees and goes even further in his analysis. The author believes that with the use of a computerized, systematic implementation, traders eliminate "...decisions driven by emotion,

indiscipline, passion, greed, and fear from the investment process.” (Narang, 2009, pp. xii) Moreover, he enhances three reasons why the practice of developing algorithmic trading strategies should be highly considered for traders to be adopted; that is the benefit of deep thought, the measurement and mismeasurement of risk, and the disciplined implementation.

### **The benefit of deep thought**

Although computers are powerful tools, they can achieve nothing without absolute precise instruction. Because of that, traders are forced to think deeply about many aspects of their strategy. In this order, an enormous amount of effort on the part of the developer is required to make a computer implement a “black-box trading strategy” (Narang, 2009).

### **The measurement and Mismeasurement of Risk**

Rather than accepting accidental risks, the disciplined trader attempts to isolate exactly what his edge is and focus his risk taking on those areas that isolate this edge. To isolate these risks, the trader must first get an idea of what these risks are and how to measure them (Narang, 2009).

### **Disciplined Implementation**

Perhaps the clearest characteristic one can learn from algorithmic trading strategies users comes from the discipline inherent to their approach (Narang, 2009). This is important because one of the biggest reasons that drives traders to failure is the lack of discipline. Narang (2009) argues that discretionary investors often find it exceedingly difficult to realize losses, whereas they are quick to realize gains. This is a well-documented behavioral bias known as the disposition effect. Computers, on the other hand, are not subject to this bias (Narang, 2009).

## **2.2. ALGORITHMS AND THE FINANCIAL MARKETS**

Although the financial world assents about the benefits and advantages of algorithmic trading, they seem to have different opinions on the size of trading operations executed by algorithms in the financial markets. The European Central Bank, (2019) believes that algorithmic trading has been growing continually since the early 2000s and estimates that algorithmic trading in some markets is responsible for around 70% of total orders of U.S. equity volumes. Treleaven et al. (2013) agree when they state that algorithms account for 73% of the trading volumes.

These numbers, however, diverge from other authors. For instance, Mukerji et al (2019) believe that algorithmic trading in U.S. stock market is responsible for no less than 85% of dollar trading volume – starting from the mid-1990s when algorithmic trading represented no more than 3 % of the volume traded volumes (Mukerji et al., 2019). Some estimates that automated trading accounts for over one-third of the trading volume in the United States alone (Chan, 2009b). This divergence is understandable because usually financial institutions and private traders do not disclose their

information about their trading systems. However, they all agree that the use of automated systems to execute trades is growing at an astounding pace. The evolution of algorithms indicates that it is paramount that traders, investment banks, or other financial enterprises that do not yet use algorithms should upgrade their trading operations to survive in the future (Narang, 2009).

### 2.3. UNDERSTANDING A BASIC STRUCTURE OF AN ALGORITHMIC TRADING SYSTEM

Rishi K. Narang's book, *"Inside the Black Box: the simple truth about quantitative trading,"* published in 2010, provides the very foundation of the structure of the algorithmic trading strategy system that is going to be used in this work (Narang, 2009). An alpha model, a risk model, and a transaction cost model are the three main modules that compound the basic structure of an algorithm trading system. These modules produce information that feeds a portfolio construction model, which in turn interacts with the execution model (Narang, 2009).

While alpha models are the part of the algorithm designed to forecast the price of the asset the trader wants to consider trading for the goal of generating returns, Risk models are developed to limit exposures that could lead traders to losses. Transaction cost models are used to identify the cost of opening or closing new trading positions (Narang, 2009).

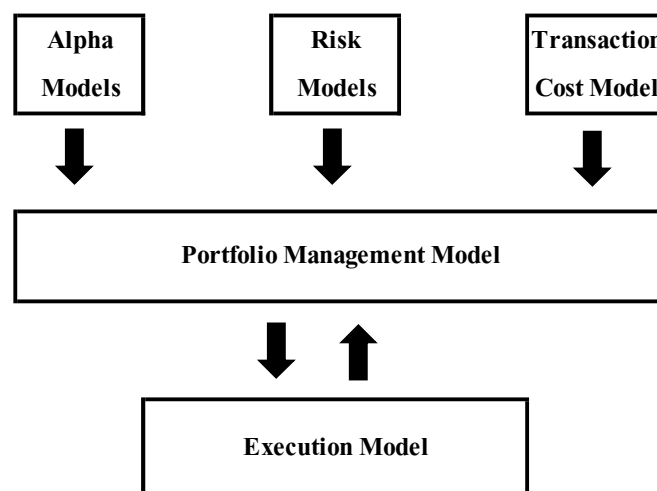


Figure 2.3.1– Basic Structure of an Algorithmic Trading System

Portfolio construction modules ponder the outputs from the alpha, risk, and transaction costs modules, determining the best portfolio to hold. Finally, the execution model initiates the process to execute the order to buy or sell the asset analyzed by the system (Narang, 2009).

### **2.3.1. Alpha Models**

Alpha models may be the main model of a trading strategy algorithm and where the research process is focused. Because they hold as core premise that no instrument is inherently good or bad they have projected to time the selection and/or sizing of portfolio holdings (Narang, 2009).

A few synonyms for an alpha model are forecasts, factors, alphas, models, strategies, estimators, or predictors. All successful alpha models are developed in a way that allows them to predict the future well enough that, after allowing for them to lose money in a few trades, they can still be profitable in the long run. Narang continuously stated that “...of the various parts of a quants strategy, the alpha model is the optimist, focused on making money by predicting the future.” (Narang, 2009, pp. 22).

#### **2.3.1.1. Types of Alpha Models: Theory Driven and Data Driven**

For a trader seeking alpha, there are a small number of basic trading strategies available that can be implemented in several ways. Understanding the perspectives quantitative traders take on science is an important element in understanding quantitative trading strategies (Narang, 2009).

Theoretical and empirical are the two major branches of science. The theoretical branch tries to make sense of the world around them by hypothesizing why it is the way it is. The empirical branch believes that enough data from the environment is enough to predict future patterns of behavior, even if there is no hypothesis to rationalize the behavior in an intuitive way (Narang, 2009).

Narang points that most of the quantitative traders are theory-driven and most of what they do can be fit into one of five categories of phenomena: trend, reversion, value/yield, growth, and quality, which can be understood by examining price-related data or fundamental data. Perceiving the inputs to a strategy is paramount to understanding the strategy itself. Trend and mean reversion trading strategies rely on price-related data while value/yield, growth, and quality trading strategies are based on fundamental data (Narang, 2009).

Traders who seek to predict prices and to profit from such predictions are likely to be using one of two kinds of phenomena. The first idea, trend following or momentum, is that, once started, an trend will continue, and the second idea, which we call counter-trend or mean reversion, is that the trend will, anywhere in the future, reverse (Narang, 2009).



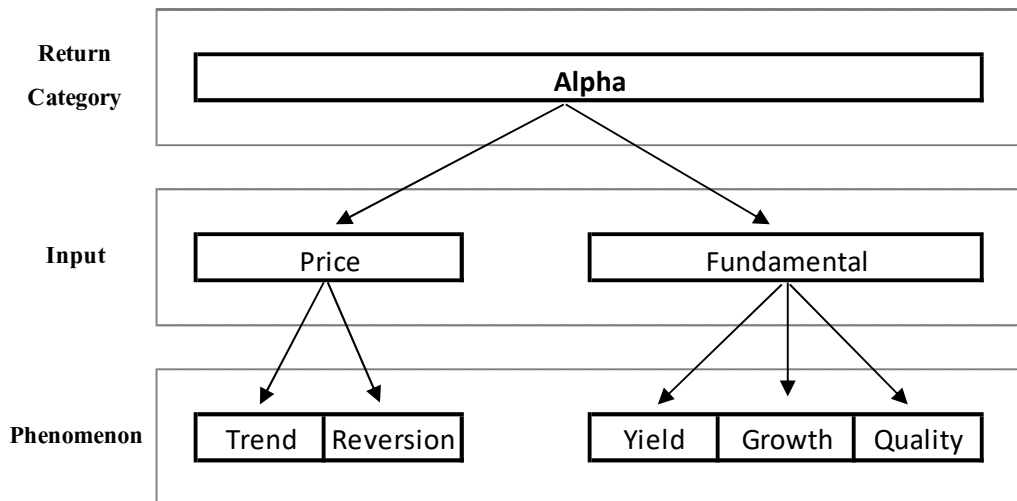


Figure 2.3.2– A Taxonomy of Theory-Driven Alpha Models

### ***Trend Following***

Trend following happens to be the oldest of all quantitative trading strategies. Ed Seykota built the first computerized version of the mechanical trend-following strategy that Richard Donchian created some years earlier, utilizing punch cards on an IBM mainframe in 1970. (Narang, 2009)

Trend following strategies are based on the theory that asset prices from time to time move in the same direction for a period sufficiently long that a trader can identify this trend and ride it. The economic theory that supports the existence of trends is based on the understanding of consensus-building among market participants (Narang, 2009).

An alternative explanation of the motive trends that happen is known as the greater fools' theory. The idea is that, by the simple fact that traders believe in trend, they tend to start buying any asset whose price is going up and selling any asset whose price is going down, which itself perpetuates the trend (Narang, 2009).

As trend followers tend to search for a meaningful move in a given direction in an instrument, one way to identify a trend for trading purposes, for instance, is to use a moving average crossover indicator. This tool compares the average price of the index over a shorter period (i.e., 50 days – the red line showed in figure 3) to that of a longer period (i.e., 200 days – the blue line shown in Figure 2.3.3) (Narang, 2009). When the shorter-term average price crosses downward the longer-term average price, the index is said to be in a negative trend. On the opposite way, when the shorter-term average price crosses upward the longer-term average, the index is in a positive trend. Figure 2.3.3 gives us examples of a few entries a trader could have used the average crossover strategy.



Figure 2.3.3– GBPUSD Daily Chart with Moving Averages (MA 50 & MA 200) Indicator

### ***Mean Reversion***

Traders practicing mean reversion strategies, also known as contrarians, believe that exists a center of gravity around which prices fluctuate. With this theory, a trader could identify both this center of gravity and the range around this center to warrant making a trade. One of the rationales behind this theory is that exists short-term imbalances among buyers and sellers due to liquidity (Narang, 2009).

Because short-term oscillations occur around longer-term trend, trend and mean reversion strategies are not always at odds with other. Mean reversion traders, after identifying the current equilibrium point of the oscillation, must determine the amount of divergence from that equilibrium is enough to make a trade feasible (Narang, 2009). Statistical arbitrage, which bets on the convergence of the prices of similar assets whose prices have diverged, is probably the best example of a mean reversion strategy.

Trend and mean reversion strategies, although they are theoretically opposite ideas, represent a large portion of all quantitative trading because they seem to work well in different timeframes. While trends occur in higher horizons, reversions tend to happen over short-term horizons (Narang, 2009).

### **2.3.1.2. Strategies Utilizing Fundamental Data**

#### ***Value/Yield***

Although this idea is used in other markets, value strategies, also known as earning yield, are usually associated with equity trading. The main idea of values strategies is that the higher the yield, the cheaper the instrument. Of the many metrics used to define value, price-to-earning (P/E) is one of the most common of them. To avoid division by zero, which could cause a dramatic error in the algorithm, quantitative traders, however, tend to invert the ratio, keeping prices in the denominator (Narang, 2009).

One of the most popular value strategies among currencies quantitative traders is the carry trade strategy. The logic of this strategy is to purchase the currency of one country with higher short-term

yields against a short position in the currency of a country with relatively low short-term yields (Narang, 2009).

### ***Growth***

The goal of growth strategies is to search predictions based on an asset's expected or historically observed level of economic growth. The gross domestic product (GDP) of a country or the earning growth of a company are good examples of that. The theory behind this idea is that, *ceteris paribus*, it is better to sell assets that are experiencing slow or negative growth or sell assets that are experiencing slow or negative growth (Narang, 2009).

### ***Quality***

Investors that pursue this quality strategy believe that, *ceteris paribus*, it is preferable to go long on assets that are of high quality to their portfolios and/or to go short on poor quality assets. The idea of this strategy is that, on one side, capital safety is important, and, on the other side, neither growth nor value strategies can identify this concept (Narang, 2009).

#### **2.3.1.3. Data-Driven Alpha Models**

The premise of Data mining is that data will most predict price movement based on some patterns recognizable through analytical techniques. One advantage of this technique is when compared with theory-driven strategies, data mining is technically more challenging and far less widely practiced. Another advantage is that data-driven strategies can identify behaviors whether they have been identified before by some theory or not. This means that these models can see events without having to understand why they happen (Narang, 2009).

Data-driven alpha models work better in short-term time horizons (i.e., minutes or less). This happens because, at this timescale, the quantity of data available can be so vast that the researcher has a better chance of finding statistically significant results in his testing (Narang, 2009).

The quantitative trader willing to practice this strategy, however, should be aware of two shortcomings. The first one is that the researcher must carefully decide what data to feed the model. The amount of data searching the algorithms, if not chosen well, could be so enormous that a huge and expensive hardware structure would be necessary to predict anything in time to make the trade. The second problem is that the generation of alphas with the use of data-mining alone could lead to false signals that act like "traps for data miners." (Narang, 2009).

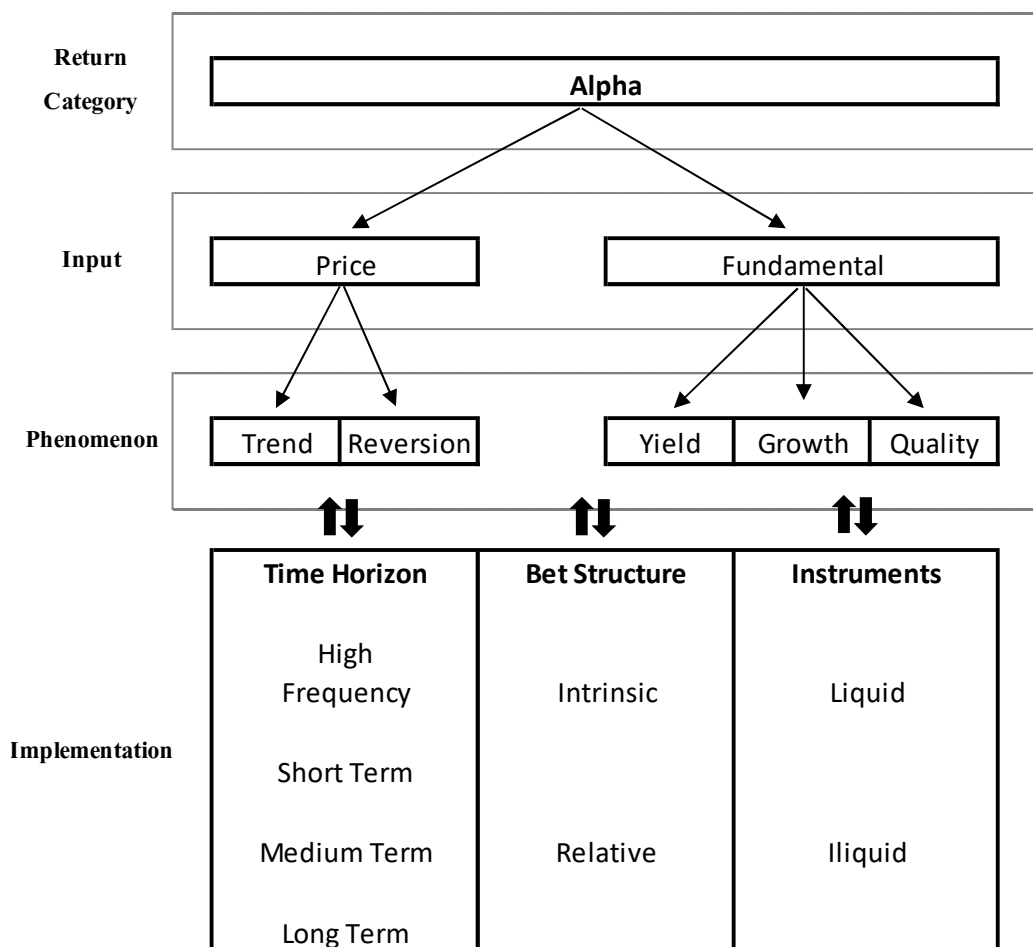


Figure 2.3.4– Taxonomy of Theory-Driven Models

### 2.3.2. Risk Models

An attentive trader should not worry only about the avoidance of risk or reduction of loss. In addition to these goals, the intentional selection and sizing of exposures to improve the quality and consistency of returns are most essential for its survival in the financial markets. Risk exposures will most likely not produce profits over the long run; however, they can seriously undermine the returns of a strategy over time. Furthermore, any attempt to forecast these risk exposures should be avoided simply because they cannot be predicted successfully. What matters is the ability to understand and measure several exposures and to be intentional about the selection of such exposures (Narang, 2009). The author continues

“... the key to understand risk exposures as they relate to quant trading strategies is that risk exposures are those that are not intentionally sought out by the nature of whatever forecast the quant is making in the alpha model.” (Narang, 2009, pp. 56)

The idea is that alpha models and risk models should present opposite perspectives. For example, if alpha models present a high probability forecast, risk models would largely control the size of desirable exposures or deal with undesirable types of exposures (Narang, 2009)

Risk management involves some knowledge on the monetary amount the trader is willing to risk in addition to the amount it is aiming to profit. Without the sense of it, traders hold on losing positions longer than they should of close profitable positions too soon (Lien, 2015). The result, continues Lien, (2015), is that the trader ends up with a negative profit/loss relation (P/L), although he may have had more winning positions than losing positions.

From the many types of risk models available, there are three main ways that a trader can have their approach in risk management. Authors, such as Basso (2019), Lien (2015), and Narang (2009), defend that position size limiting, risk-reward ratio, and stop-loss order represents a high degree of importance for risk management.

Limiting the size or eliminating it can work as an alternative to just accepting a given type of exposure. The trader, now in the role of a risk manager, should determine which of these courses of action is appropriate for each kind of exposure and feed the risk model to assess if the trade is worth taking or not (Narang, 2009).

How size is limited can be mainly approached by constraint or penalty forms. Hard constraints, as the name suggests, are set to establish a fixed position in terms of risk (Basso, 2019). For example, no position should be larger than 3% of the account balance, however, because the distance from the entry price to the stop-loss order price vary from trade to trade, the contract size of the position is adjusted so the risk does not increase. The penalty function work in a way that will allow a position to be greater than 3% but will impose heavier penalties to allow that. These penalties through research can be determined either from the data or from theory (Narang, 2009).

Setting a risk-reward ratio to trading strategies is a powerful tool to keep a positive profit and loss ratio and to prevent traders from opening positions that ultimately are not worth the risk. It allows the strategy to have an exact amount of how much profit the trade should achieve against the amount risked opening the position (Lien, 2015). Thus, the risk-reward ratio varies from strategy to strategy, but as a 'rule of thumb', according to Lien (2015), it should be no less than 1:2.

Finally, Stop-loss orders, alongside with risk size limiting and risk-reward ratio, are essential to control your losses, in line with position risk size. Setting the limit to your losses avoids the common predicament of being in a scenario where strategies have a high probability of profitable trades but a loss large enough to give all the profit back to the market (Basso, 2019). Thus, the author suggests that it is a good habit to move the stop-loss order to the break-even level as soon as the position has profited by the same amount initially risked for the trade. She also points that some strategies choose to close a portion of the position once profit equals the amount risked.

Managing risk daily basis not only can reduce the volatility of the return of a strategy, but also, and far more important, can reduce the likelihood of large losses. In many cases, the failures of some quantitative traders are directed associated with failures to manage risk (Narang, 2009).

### **2.3.3. Transaction Cost Models**

Narang describes a transaction cost model as "a way of quantifying the cost of making a trade of a given size so that this information can be used in conjunction with the alpha and risk models to

determine the best portfolio to hold.” The model will decide if the cost of opening a position is worth it or not. Furthermore, on one hand, if the cost of transacting is underestimated, the algorithm could be led to make too many trades that would have insufficient benefit. On the other hand, overestimating the cost of transacting could lead the algorithm to miss trading opportunities or to hold positions too long (Narang, 2009).

Transaction cost models can be explained in two basic types: flat, linear, piecewise-linear, and quadratic. A flat transaction cost model means that the cost of trading is constant no matter the size of the order. A linear transaction cost model means that the cost grows on the same scale as that of the transaction size (Narang, 2009).

#### **2.3.4. Portfolio Construction Models**

The decision to allocate assets in a portfolio is based on an equilibrium of considerations of expected return, risk, and transaction costs. Quantitative portfolio construction models are defined by a rule-based portfolio construction model, which is based on heuristics defined by the quantitative trader, and optimized portfolio construction models such as the Markowitz (1952) modern portfolio theory and the Tobin (1958) two-fund separation theorem, which utilizes step-by-step sets of rules designed to get the user from a starting point to the desired point (Narang, 2009).

### **2.4. FOREIGN EXCHANGE MARKETS**

The world’s financial markets are vast, in terms of both the size and diversity of products they incorporate. Generally speaking, the financial market can be broken down into four main categories, namely: i) capital markets; ii) foreign exchange markets; iii) money markets; and iv) derivative markets (Johnson, 2010). For the sake of simplicity, this work will focus its attention only on foreign exchange markets.

Foreign exchange markets, at their most basic level, are over-the-counter markets with no central exchange and clearing house where orders are matched. Foreign exchange dealers and markets makers around the planet are linked to each other around the clock creating one cohesive market (Lien, 2015).

As the largest and fastest markets in the world, foreign exchange markets allow traders to operate 24-hour per day, 6-days per week in a market with an average daily volume of transactions of \$6,6 trillion U.S. dollars (Bank for International Settlement, 2019). Johnson (2010) gives us a sight of the potentiality of the forex markets when he states that

“...it’s 24-hour nature offers traders instant access to the markets at all hours of the day for immediate response to global developments. Different times of the day will offer different trading opportunities, as the global financial centers around the world are all actively involved in foreign exchange “ (Lien, 2015, pp. 21 ).

As these markets became accessible to trade by individual retail investors around twenty years ago, and because they present such attractive characteristics, foreign exchange markets exploded in popularity (Lien, 2015).

## 2.5. POSITION SIZING AND RISK ALLOCATION

The establishment of the volume of trade, along with the Buy/Sell Engine, which is the entry-level and the stop-loss size, and the maximum risk allocation for a trade, makes up the structural tripod for risk management in trading operations (Basso, 2019).



Figure 2.5.1 – The trade Tripod

Among different forms available of calculating it, Basso (2019) provides two popular techniques to calculate the volume for a single trade. The first one uses the monetary value of the risk of the trade has a divisor, which is the difference between the current bid/ask price and the stop-loss limit price established for that single trade – see formula (1). The second technique utilizes the Average True Range (ATR) indicator, which measures the volatility of a specific asset in a given period – see formula (2).

$$lotSize(Risk)_t = \frac{currentBalance_t \times riskPercentage_t}{stopLoss_t} \quad (1)$$

$$lotSize(Volatility)_t = \frac{currentBalance_t \times riskPercentage_t}{ATR_t} \quad (2)$$

Where, *currentBalance* is the monetary value of the equity in the account at the moment of the trade, *riskPercentage* is the current portfolio risk in percentage allocated to a single position, *stopLoss* is the monetary risk on the upcoming trade, and ATR is the average True Range indicator value.

Concerning risk allocation, there is no consensus in the literature for the definition of a fixed value corresponding to a maximum risk, in percentages, to allocate in a single trade. (Narang, 2009), suggests the amount of 3% of the current portfolio equity, allowing the automated system to raise the risk allocation to 5% if the alpha model emits a strong signal. Basso (2019), on the other hand, proposes that maximum risks could vary from 0.5% to 2% of the account balance, depending on the trader's appetite for risk.

## 2.6. TECHNICAL INDICATORS

Over time, although traders have been developing and using technical indicators to aid them in the prediction of price movements in the various markets, the topic has received significantly less attention in the literature (Neely et al., 2014). Technical indicators are heuristic or pattern-based signals that rely on past price, volume patterns, or/and open interest of an asset to identify price trends believed to persist into the future; see James (2021) and Neely et al. (2014) for recent surveys.

### 2.6.1. Moving Average Indicator

As one of the first trading tools ever invented (Narang, 2009), and because of its simplicity and intuitive appeal (Guo et al., 2017), the moving average (MA) is one of the most popular technical indicators (Zhu & Zhou, 2009). The MA is a technical analysis tool that smooths out price data over a specific period by creating a constantly updated average price (Cory, 2021).

The common moving average formula is given by

$$MA = \frac{P_1 + P_2 + P_3 + \dots + P_n}{n} \quad (3)$$

$$MA = \frac{1}{n} \sum_{i=0}^{n-1} P_{n-i} \quad (4)$$

Where  $MA$  is the moving average value,  $P_n$  is the price of an asset at period  $n-1$ , and  $n$  is the number of total periods.

### 2.6.2. Average Directional Index Indicator

Created by (Wilder Jr., 1978), the Average Directional Index (ADX) is a trend-following technical analysis indicator that some traders use to determine the strength, or the magnitude, of a trend (Mitchell, 2021), but not the actual direction of the later. It is used together with an positive directional indicator (DI+) and a negative directional indicator (DI-), which identifies if there is a trend



(Gurrib, 2018). See formula (5). For a better understanding of the formula, see Wilder Jr. (1978) and Gurrib (2018, pp. 62-63).

$$ADX_t = \begin{cases} \frac{1}{n} \sum_{t=1}^n DX_t, & \text{if } t = 1 \\ \frac{1}{n} ((ADX_{t-1} \times (n-1) + DX_t), & \text{if } t \geq 2 \end{cases} \quad (5)$$

$$DX_t = \left| \frac{DI_t(+)-DI_t(-)}{DI_t(+)+DI_t(-)} \right| \quad (6)$$

$$DI_t(\pm) = \frac{100}{nTR_t} \times (DM_t(\pm)) \quad (7)$$

$$DM_t(+)= \begin{cases} (High_t - High_{t-1}), & \text{if } (High_t - High_{t-1}) > (Low_t - Low_{t-1}) \\ 0 & \end{cases} \quad (8)$$

$$DM_t(-)= \begin{cases} (Low_{t-1} - Low_t), & \text{if } (Low_{t-1} - Low_t) > (High_t - High_{t-1}) \\ 0 & \end{cases} \quad (9)$$

$$TR_t = Max \begin{cases} High_t - Close_{t-1} \\ Low_t - Close_{t-1} \end{cases} \quad (10)$$

Where  $n$  is the period set to the ADX,  $DX$  is the directional index,  $DI(\pm)$  is the positive and negative directional indicator,  $DM(\pm)$  is the directional movements, and  $TR$  is the True Range indicator.

### 3. METHODOLOGY

This chapter outlines the methods applied to this work. It provides information on the programming language, the hardware, and trading platform software utilized to write and execute the automated trading system. Thus, information about the data that will feed the trading model and the reasons for selecting the assets to be tested. The researcher describes the trading strategy that we have chosen for this study and the reasons. It also details the process of construction of the algorithm data that will feed the trading model.

#### 3.1. HARDWARE, SOFTWARE, AND THE PROGRAMMING LANGUAGE

The trading platform selected to execute the automated trades was the MetaTrader 5, and the programming language used to write the algorithm was the MetaQuotes Language 5 (MQL5), “an object-oriented high-level programming language intended for writing automated trading strategies” (‘MQL5 Reference’, 2021). The reason for the choice of this trading platform was due to its accessibility to the general public. Its license to use is free of charge. Nevertheless, the choice for the programming language, which was developed by the same enterprise that developed the trading platform, makes it easier to integrate the trading system to the trading platform.

Because there is no mention in the MQL5 Reference Book about its coding standards and style, and because the language structure and syntax are heavily based on the C++ programming language, the researcher decided to follow the C++ Coding Standards available at the Standard C++ Foundation (‘C++ Core Guidelines’, 2021) to write the algorithm.

The algorithm used in this work was entirely written by the author of this thesis, who is not a professional code programmer. It is essential to emphasize the non-professional part because, in the eye of someone with high code skills, the algorithm could present opportunities for improvements in its structure and efficiency. With that in mind, we quote Eric Evans

Good programming style [...] is still an exercise in self-discipline. It takes fastidiousness to write code that does not just do the right thing but also says the right thing (Evans, 2004, pp. 40).

The hardware used in this research to execute the back-testing of the strategy was an Intel(R) Core (TM) i5-4590 CPU @ 3.30GHz 3.30 GHz, 32GB of RAM, and the operating system was Windows 10.

#### 3.2. THE DATA AND THE ASSETS

The automated trading system used daily bars containing the open, the high, the low, and the close prices to feed the model. The period for data collection started on January 1st, 2004, and ended on December 31st, 2020. BDS Swiss Markets Global Services Ltd<sup>1</sup>, the broker, provided the quotes that fed the system.

---

<sup>1</sup> <https://www.bdswiss.com/>

The currency pairs of choice for the back-testing were the Euro vs. the U.S. Dollar (EUR/USD), the British Pound vs. the U.S. Dollar (GBP/USD), the Australian Dollar vs. U.S. Dollar (AUD/USD), the New Zealand Dollar vs. the U.S. Dollar (NZD/USD), the U.S. Dollar vs. the Japanese Yen (USD/JPY), the U.S. Dollar vs. the Canadian Dollar (USD/CAD), and the U.S. Dollar vs. the Swiss Franc (USD/CHF).

As one can notice, the researcher selected only currency pairs with the U.S. Dollar on one of its sides. The determinant reason for that was that a BIS Triennial Central Bank Survey that the Monetary and Economic Department of the Bank for International Settlements released in 2019 showed that the FOREX markets reached \$6,6 trillion per day in April 2019. Furthermore, 88% of all trades had the U.S. Dollar on one side of the transaction (Bank for International Settlement, 2019).

### **3.3. THE AUTOMATED TRADING SYSTEM**

This experiment aims to code and execute the Perfect Order Strategy<sup>2</sup> in a fully automated trading system on the foreign exchange markets. Lien (2015) describes the strategy in chapter 16 of her book *Day Trading and Swing Trading the Currency Market*.

The Perfect Order strategy seeks to identify a trending environment in its early stage. The strategy makes use of a set of six technical trending indicators to generate an entry signal: five moving averages ; MA(10), MA(20), MA(50), MA(100), MA(200), and an average directional index indicator (ADX) . If the moving averages align upwards, a potential bullish trend is identified; if the MA align downwards, a potential bearish trend identified. Moreover, the ADX current value must be equal or higher than 20. A signal is triggered if, and only if, the condition is maintained for five consecutive daily bars (Lien, 2015). Chapter 3.3.1 – The Alpha Model Algorithm gives full detail of the strategy.

The reason for the choice was because the strategy is theory-based and utilizes price data as inputs to generate buy and sell signals. Thus, the Perfect Order strategy relies on a trending phenomenon, the oldest and the most used indicator among traders (Narang, 2009). Finally, the fact that the author describes the procedures to implement and execute the strategy contributed to choosing the strategy.

The author of this work developed an automated trading system, which was adapted from the system suggested by (Narang, 2009), consists of four main modules: the Alpha model, the Risk model, the Execution model, and the Position Management model (our contribution to Narang's automated system). The alpha model, which is the model that receives the core of the strategy, generates a buy or a sell signal when all conditions defined by the strategy are met.

The model then sends the signal to the risk model that will access the risk and validate or not the trade. In case the trade is not authorized, the module will abort the execution, on the contrary, the execution model receives the authorization to fill the buying or selling order and send it to the broker. Once the trade is open and running, the Position Management model verifies if the condition set by the strategy is still valid. Once this condition is no longer true, the model closes the position.

---

<sup>2</sup> By strategy, we mean "a plan or method for achieving something, especially over a long period of time." <https://www.macmillandictionary.com/dictionary/british/strategy>

The processes of the automated trade system are shown in a simplified diagram in Figure 4.3.1 – The Automated Trading System Diagram below.

From this point on to the rest of this subchapter, we will go through each module to demonstrate how the strategy was constructed and translated into code lines that had fully automated.

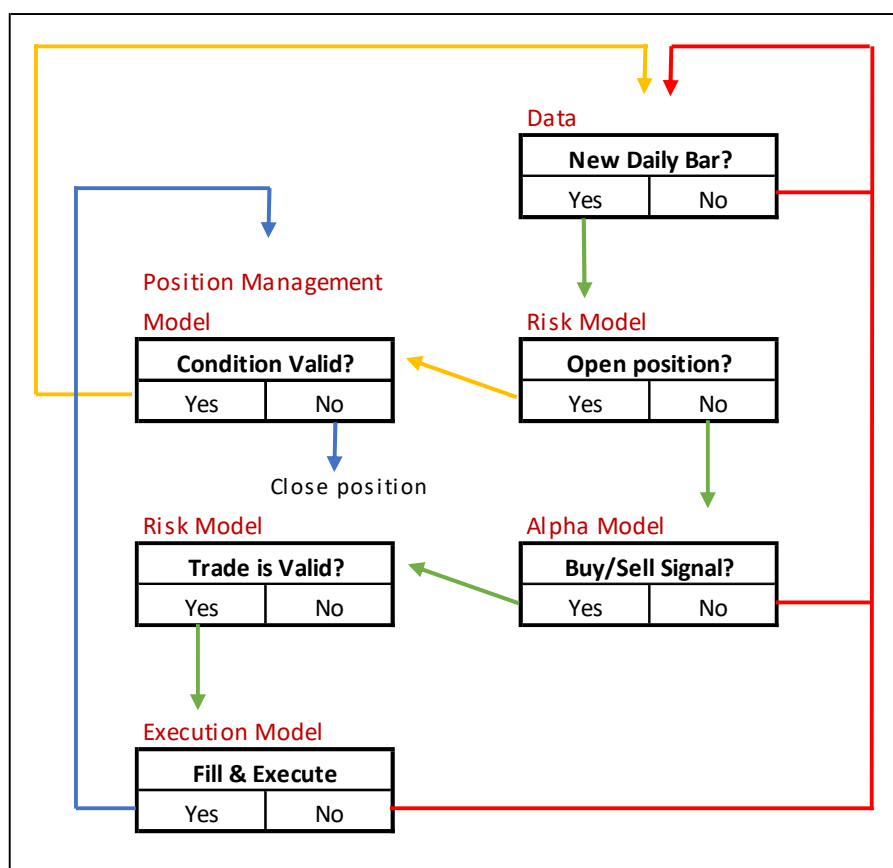


Figure 3.3.1 – The Automated Trading System Diagram

### 3.3.1. The Alpha Model Algorithm

Has stated before, the Alpha model holds the core of the strategy, and it is responsible for scanning the asset chosen for the experience and emitting a signal for a potential trade. The trading strategy, as proposed by (Lien, 2015) in her book *Day Trading and Swing Trading the Currency Market*, holds a set of six indicators: five simple moving averages (SMA) indicators and one strength trend indicator, the Average Directional Movement Index (ADX) (Lien, 2015). Thus, according to the author, the trading strategy “seeks to take advantage of a trending environment near the beginning of the trend.” Below is a summary of the strategy, as is stated on page 155 of chapter 16 of the author’s book.

1. Look for a currency pair with moving averages in perfect order.
2. Look for ADX ideally greater than 20.

3. Buy five candles after the initial formation of the perfect order (if [conditions] still hold).
4. Initial stop in the low on the day of the initial crossover for longs and the low for shorts.
5. Exit the position when the perfect order no longer holds.

Table 3.1 – Characteristics of the Perfect Order Strategy

Has we can deduct from the table above, the Perfect Order strategy requires the agreement of three conditions to generate, or trigger, a buy or a sell signal. The first confirmation signal is triggered when the moving averages align in “perfect order”(Lien, 2015), which is an ordered sequence of the moving averages that confirms the asset under consideration is in an upward or a downward trend.

The first SMA indicator is set for ten days, the second SMA is set for 20 days, the third is set for 50 days, the fourth is set for 100 days, and the fifth SMA is set for 200 days (From now on, the simple moving averages will be referred to as SMA(period) and Average Directional Movement Index as ADX(period). For example, a simple moving average with a 20-day period will be referred to as SMA(20) and an ADX with a 14-day period as ADX(14).

In an upward trend, a buy signal is generated when the SMA (10) value is higher than the SMA (20) value, which is higher than the SMA (50) value. Nevertheless, the SMA (100) value is greater than SMA (200) and lower than the SMA (50). That is, a buy signal will be true when, and only when  $SMA(10) > SMA(20) > SMA(50) > SMA(100) > SMA(200)$

Figure 3.3.2 (Perfect Order Strategy Buy Model Sample) and Figure 3.3.2 (Perfect Order Strategy Sell Model Sample) give the reader a visual understanding of the use of the strategy in the context of an upward trend or a downward trend.

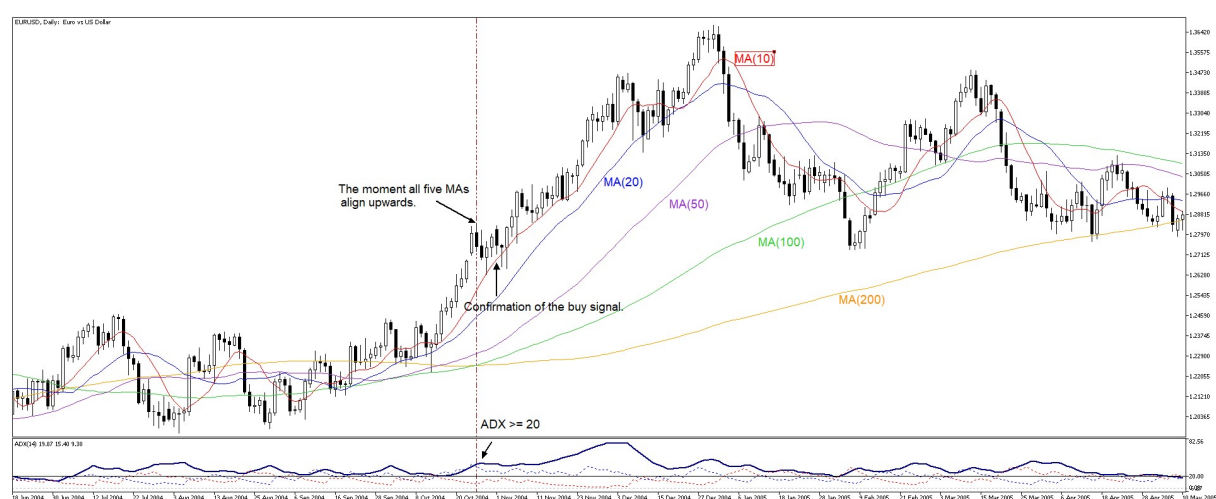


Figure 3.3.2 – Perfect Order Strategy Buy Model Sample

In a downtrend, the opposite is true. A sell signal is triggered when, and only when  $SMA(10) < SMA(20) < SMA(50) < SMA(100) < SMA(200)$



Figure 3.3.3 – Perfect Order Strategy Sell Model Sample

The Average Directional Index (ADX) indicator gives the second confirmation condition. The condition will be true when the ADX(14) value is above 20 and is in an upward trend (See graph 1 and graph 2). Finally, the third and last confirmation signal is generated if, and only if, the two aforementioned conditions remain true after five daily bars.

Figure 4.3.2. (Signal Conditions 1 and 2) shows a Boolean vector, or an array, that will store each verification. When conditions 1 and 2 are true, that is, the MA is in perfect order, and the ADX is above 20, a true value will be added to the first position of the array.

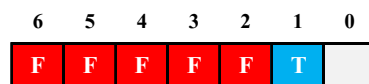


Figure 3.3.4 – Signal Conditions 1 and 2

As we can see in Figure 4.3.3 (Confirmation Vector) below, as long as conditions 1 and 2 are valid, the module should add true values to the Boolean array up to five positions. If an array-like array shown in Figure is formed, all three conditions are met, and the Alpha model will emit a buy or a sell signal to the risk model, which will in turn access the risk of the trade. Once authorized, the module triggers the execution module function, which will fill and send a buy/sell order to the broker at the market price at the opening of the sixth daily bar.

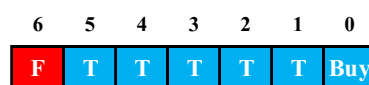


Figure 3.3.5 – Signal Confirmation Vector

Now that we understand the core of the strategy that supports the alpha model, we will go through the code of its functions. Because of its irrelevance to the scope of this discussion and to keep the text as clean as possible, part of the code of the referred model function is omitted. This omission is related to data error treatments that have no direct relation with the strategy. Annex I, at the end of this work, holds the complete algorithm of the Alpha model used in this experiment.

Because the Perfect Order strategy requires that a buy/sell order be executed after five complete bars, i.e., at the opening of the sixth bar, the algorithm will call the alpha model at the beginning of every new candle to check the conditions for the signal of the last five bars. If all conditions are true, as shown in figure 4.3.3, then a valid buy/sell signal is generated.

To be able to test these conditions, the algorithm first stores Boolean values in an array that will test for long conditions and another array that will test for short conditions. Each true/false value represents the conditions required by the strategy up to five bars. This action is shown in Figure 3.3.7 (Alpha Model Algorithm (lines 133 to 146)).

```

133 // Fill buy/sell arrays
134 for(int i=1; i<=bars-1; i++)
135 {
136     // Buy signal
137     buySignal[i-1] = (fastMA1Array[i] > fastMA2Array[i] &&
138                     fastMA2Array[i] > midMAArray[i] &&
139                     midMAArray[i] > slowMA1Array[i] &&
140                     slowMA1Array[i] > slowMA2Array[i]);
141     // Sell Signal
142     sellSignal[i-1] = (fastMA1Array[i] < fastMA2Array[i] &&
143                      fastMA2Array[i] < midMAArray[i] &&
144                      midMAArray[i] < slowMA1Array[i] &&
145                      slowMA1Array[i] < slowMA2Array[i]);
146 }

```

Figure 3.3.6 – Alpha Model Algorithm (lines 133 to 146)

To prevent the algorithm from returning false-true signals, the entry signal must be triggered at the beginning of the trend. One way to assure that, and because the entry is signaled after the conditions remain true for five daily bars, is to certify that the sixtieth candle in the Boolean array is always false.

Once the arrays are filled with Boolean values, the alpha model goes through each vector to verify if the conditions for trade are met. The result of this analysis is stored in the string variable *signal* that has a standard 'doNothing' value in case no trading signal is generated. This standard value signals the algorithm to do nothing and wait for the opening of the next candle and repeat the process because no trading signal was identified by the alpha model.

If, however, the model identifies conditions for longs, the algorithm attributes a 'buy' value to the string variable; or, if it identifies conditions for shorts, the algorithm attributes a 'sell' value to the string variable. See Figure 3.3.8 (Alpha Model Algorithm (lines 148 to 164)).

```

148 // If a buy signal is confirmed after 5 candles
149 string signal = "";
150 if(buySignal[0] == true && buySignal[1] == true &&
151    buySignal[2] == true && buySignal[3] == true &&
152    buySignal[4] == true && buySignal[5] == false&&)
153 {
154     signal = "buySignal";
155 }
156 // If sell signal is confirmed after 5 candles
157 else if(sellSignal[0] == true && sellSignal[1] == true &&
158    sellSignal[2] == true && sellSignal[3] == true &&
159    sellSignal[4] == true && sellSignal[5] == false&&
160    adxArray[1] >= 20)
161 {
162     signal = "sellSignal";
163 }
164 else signal = "noSignal";

```

Figure 3.3.7 – Alpha Model Algorithm (lines 148 to 164)

### 3.3.2. The Risk Model Algorithm

The risk model of our trading system has in its core the role to access risks to the potential trade and to set the attributes, i.e., the lot size and stop-loss price, that the execution model will use to fill the entry orders. Once the alpha model confirms the entry signal, the risk model function is then called to verify if the potential trade fulfills three basic conditions:

- i) it certifies that there are no open positions;
- ii) it verifies that the stop-loss price is valid, and
- iii) it calculates the volume, or lot size, for the potential trade. If these conditions are met, the Risk model will return 'buy\_order\_approved' value for long signals and 'sell\_order\_approved' value for short signals, and 'tradeRejected' if the Risk model rejects one of the conditions.

In the first condition, the model certifies that there is no open position at the time the Alpha model triggers a buy or sell signal. This simple action is a measure to prevent the trading system to open multiple positions and do not overtrade, which could overleverage the account creating margin level risk which could ultimately lead the broker to close positions and jeopardize the account balance.

Furthermore, because the strategy aims to identify a trend in its beginning (Lien, 2015) and it does not foresee additions to the first trade, the trading system should emit one signal per trend and hold one open position at a time. This simple verification also prevents the algorithm from opening additional trades from unexpected true-false signals. For instance, if the system already has an open long position and, for any unknown reason, the alpha model triggers a short signal, the risk model will reject this new signal. See Code 4.3.1.3 (Check for Open Positions below).



```

184 // Check for open positions
185 if(PositionsTotal() > 0) return("tradeRejected: position already open.");

```

Figure 3.3.8 – Check for Open Positions

Once the Risk model clears the first condition, the function sets the stop-loss limit price for the potential trade. The author states that the stop-loss for the entry is the lower price of the fiftieth bar of the alignment of the Moving Averages (Lien, 2015). During this process, the model reads the lower price of the fifth daily bar for a buy order and verifies if the stop-loss limit price is valid as shown in Figure 3.3.10 (Setting the Stop-loss Limit price for a long position algorithm).

```

194 stopLoss = barInfo[5].low;
195 double ask = NormalizeDouble(SymbolInfoDouble(_Symbol, SYMBOL_ASK), _Digits);
196 if((stopLoss <= 0) || (stopLoss >= ask)) return "tradeRejected: SL incompatible with trade";

```

Figure 3.3.9 – Setting the Stop-loss Limit price for a long position algorithm

There are several ways to check if the stop-loss condition is valid. One way to verify the validity of the condition is to confirm that the value attributed to the variable that holds the stop-loss price is higher than zero. A negative value will cause the broker to reject the order. Another way is to certify that the stop-loss price in a buying order is lower than the entry price and higher than the entry price in a selling order. In case the condition returns false, the Risk model rejects the trade.

Finally, the third and last condition is where the Risk model evaluates the lot size for the trade. (Basso, 2019) provides a simple but powerful formula to assist us in this purpose. The formula, as shown in formula 5, is based on the risk in percentage that the trading system is allowed to take in a single trade. This mechanism allows the Risk model to adjust the volume size for a particular trade based on the current balance account at the time of that trade. The logic behind it is that, according to the author, in one hand, at the pace the automated system profits from the strategy and the account balance growth, the system updates the lot size for future trades to maintain the growth rate, and on the other hand, when the systems fail to take profits and loses money, the system than lower the risk it takes for the next trades to adjust to the reality of the smaller account balance (Basso, 2019).

$$lotSize = \frac{riskSize\% \times accountBalance}{SLpips \times pipValue} \quad (5)$$

To calculate the volume of the current trade the trading system makes use of three variables:

- i) the amount of money the system is allowed to risk in a single trade (*moneyRisk*),

- ii) the size, or range, of the stop-loss in pips (*SLpips*), and
- iii) the value of a pip for a standard lot size at the moment of that specific trade (*pipValue*). The risk in the monetary unit is the product of the multiplication of the risk allowed per trade in percentage (*riskSize%*) and the current account balance (*accountBalance*). Thus, the risk in percentage is a constant value that the manager of the automated trading system previously set. Code 4.3.2.4 “Trade lot-sizing algorithm for a long position” shows how this is done in lines 203 and 204 of the algorithm.

After evaluating the risk in monetary units for the trade, the system calculates the value of a pip and the stop-loss size through a set of simple rules (see-through lines 205 and 227 in Code 4.3.2.4). To calculate the value of a pip, the Risk model first needs to identify the currency pair that it is going to back-test. Because the currency of the account used in the back-testing is in the U.S. dollar, the value of a pip for one standard lot will be \$10 for any currency pair that has the U.S. dollar as the quoted currency (Chen, 2021).

For the currency pairs where the U.S dollar is the base, the value of a pip is \$10 divided by the last ask quote, for longs, or the last bid quote, for shorts. In the case of pairs where the quoted currency is Japanese Yen (JPY), such as the USD/JPY pair, it is necessary to multiply the result of the division by 100 to adjust the value (see-through lines 206 and 218 in Code 4.3.2.4).

Finally, the stop-loss in pips is the difference of entry price and the stop-loss price for long positions or the difference between the stop-loss price and the entry price for short positions. The system then multiplies this value for 10.000 for any currency pair other pair that has JPY as the quoted currency, which in this case the value is multiplied by 100 (see-through lines 220 and 227 in Code 4.3.2.4)

```

202 //---Calculating the contract size
203 double accountBalance = NormalizeDouble(AccountInfoDouble(ACCOUNT_BALANCE), ACCOUNT_CURRENCY_DIGITS);
204 double moneyRisk = balance * riskSize;
205 //- Calculating the value of 1 basis point (1 pip)
206 double pipvalue = 0.0;
207 //
208 if(_Symbol == "EURUSD" ||
209     _Symbol == "GBPUSD" ||
210     _Symbol == "NZDUSD" ||
211     _Symbol == "AUDUSD") pipvalue = 10.0;
212 else if(_Symbol == "USDCAD" || _Symbol == "USDCHF") pipvalue = NormalizeDouble(10/ask, _Digits);
213     else if(_Symbol == "USDJPY") pipvalue = NormalizeDouble((10/ask)*100, _Digits);
214     else
215     {
216         Print(_Symbol, " is not a tradable Asset. Select a new asset.");
217         return "tradeRejected: invalid asset.";
218     }
219
220 // Adjusting base values for setting the stop-loss size
221 double SLpips = 0.0;
222 //
223 if(_Symbol != "USDJPY")
224 {
225     SLpips = NormalizeDouble((ask - stopLoss) * 10000, 1);
226 }
227 else SLpips = NormalizeDouble((ask - stopLoss) * 100, 1);
228
229 lotSize = NormalizeDouble(moneyRisk / (SLpips * pipvalue), 2);
230 ArrayFree(barInfo);
231 //
232 return "buy_order_approved";

```

Figure 3.3.10 – Trade lot-sizing algorithm for a long position algorithm

With the risk in monetary units, the stop-loss size, and the value of a pip values stored, the model will then use it to calculate the volume for the very next trade. Afterward, the risk model returns the type order approved string to the main function (see Figure 3.3.11 (Trade lot-sizing algorithm for a long position algorithm) which, in its turn, will call the Execution Model to proceed with the order execution.

### 3.3.3. The Execution Model Algorithm

The function of the Execution model in our automated trading system is to fill the trading orders and send them to the broker to execute them. Once the Risk model approves the transaction, the model updates the last quote for the currency pair it is trading, adds to the order the stop-loss limit price that the strategy determined and the Risk model validated, and sends the order to the broker, which in his turn executes it.

Figure 4.3.12 (Execution Model for a Buy Order Algorithm), through lines 292 and 315, shows how this is done if the system is executing a long order. With a position open and with the rule that the system will have one open trade per time, the automated system will enter in standby mode, and the Position Management mode will take over the system while the position is open.

```
292 if(execute_trade == "buy_order_approved")
293 {
294     trader.Buy(lotSize,
295         _Symbol,
296         SYMBOL_ASK,
297         stopLoss,
298         0,
299         "sp: " + IntegerToString(SYMBOL_SPREAD));
300
301     // Check trade request status
302     Print("Execution result: ", trader.ResultRetcodeDescription());
303 }
304 //--- Execute a SELL order
305 if(execute_trade == "sell_order_approved")
306 {
307     trader.Sell(lotSize,
308         _Symbol,
309         SYMBOL_BID,
310         stopLoss,
311         0,
312         "sp: " + IntegerToString(SYMBOL_SPREAD));
313
314     // Check trade request status
315     Print("Execution result: ", trader.ResultRetcodeDescription());
316 }
```

Figure 3.3.11 – Execution Model for a Buy Order Algorithm

### 3.3.4. The Position Management Algorithm

Once the position is open, it will remain open until one of two conditions are met. The first condition is triggered when the forex pair quote hits the stop-loss limit order. In this case, the broker is responsible for closing the trade because it accepted the stop-loss limit order the Execution model filled at the trading order. The second condition follows a demand of the strategy. The author states that “the trade remains open until the conditions are no longer valid.” (Lien, 2015). By conditions no longer being valid we, understand that when the Moving Averages are no longer aligned. This alignment is lost when the MA(10) crosses downward the MA(20) in a long position or when the MA(10) crosses upward the MA(20) in a short position.

The only function of the Position Management module is to verify, at every new daily candle, if the Moving Averages are aligned. This Module is an adaptation of the trading system that Narang (2009) suggested making viable the position management condition of the Strategy. Once this condition returns false, the module closes the trade at market price; see Figure 3.3.13 (Position Management Algorithm). Finally, with no open position being held, the automated trading system calls the Alpha Model to search the asset for a new trend and the cycle begins.

```
350 // If position is a buy
351 if(trader.RequestType() == ORDER_TYPE_BUY)
352 {
353     if(MA1Array[1] < MA2Array[1])
354     {
355         trader.PositionClose(trader.RequestSymbol());
356         Print("Execution result: ", trader.ResultRetcodeDescription());
357     }
358 }
359 // If position is a sell
360 else if(trader.RequestType() == ORDER_TYPE_SELL)
361 {
362     //--- Test if condition holds
363     if(MA1Array[1] > MA2Array[1])
364     {
365         trader.PositionClose(trader.RequestSymbol());
366         Print("Execution result: ", trader.ResultRetcodeDescription());
367     }
368 }
```

Figure 3.3.12 – Position Management Algorithm

## 3.4. THE BACK-TESTING

To execute the back-testing on the currency pairs detailed in section 4.2 of this chapter, the author of this work used the “Strategy Tester” function, or tool, available in MetaTrader 5 trading platform software. For each selected FX symbol, the tester executed the strategy with the following settings:

- Strategy: Perfect Order Strategy
- Period tested from January, 1<sup>st</sup>, 2005 to December, 31<sup>st</sup>, 2020
- Timeframe: Daily
- Delays: 40ms
- Modeling: every tick
- Initial Deposit: 100.000 USD

- Leverage: 1:100

Figure 3.4.1 (Strategy Tester Settings for USD/CHF Back-testing) details all inputs used in the execution of the back-testing of the strategy.

Once the execution is done, the tool generates a Log report where the Strategy tester tool reports every single event that occurred during the back-testing, both from the automated trading system and from the tool itself. We can look at it as the “back-end” part of the project where we can verify how the algorithm behaved during the tests. The complete log reports of every selected currency pair are available in attachments of this research.

After the automated trading system finished the back-testing, the results are presented in Chapter 5 “Results and Discussion” where we examine and discuss several metrics and resulted from the back-testing. We split the analysis into three branches. In the first branch, we look at the data such as the number of bars and ticks available for the test and to the signals the Alpha Model has generated, in particular to the rejected signals and the motives that brought the trading system or rejected them. In the second branch, we examine the profit or loss of each trade, the size of risk (stop-loss size) the system took in each one of them, and the reward-risk ratio resulting from these trades.

Finally, in the third branch, we go over the overall results of the back-testing. We look at performance metrics such as total net profit, gross profit and loss, balance absolute and relative drawdown, equity absolute and relative drawdown, position holding time, among other indicators.

The screenshot displays the 'Strategy Tester' settings window. The 'Expert' dropdown is set to 'masters\_project\perfect\_order\_v6.1.ex5'. The 'Symbol' is 'USDCHF' and the 'Timeframe' is 'Daily'. The 'Date' range is from '2005.01.01' to '2020.12.31'. The 'Forward' is set to 'No' with a date of '2020.07.24'. The 'Delays' are set to '40 ms' with a checkbox for 'emulate slippage and requotes during trade execution'. The 'Modelling' is set to 'Every tick' with a checkbox for 'profit in pips for faster calculations'. The 'Deposit' is '100000' USD with a '1:100' leverage. The 'Optimization' is set to 'Slow complete algorithm' with a 'Custom max' range.

Figure 3.4.1 – Strategy Tester Settings for USD/CHF Back-testing

At the end of Chapter 5, we analyze the combined overall results of back-tested symbols. On one side, we point to factors where the strategy showed strength and on the other side, we look at aspects and events where the strategy was weak and failed to profit. With this information in hand, we offer the reader particular insights into the Perfect Order strategy that could be useful to improve it through further research.

## 4. RESULTS AND DISCUSSION

For the back-testing of the samples, we analyzed the performance of the Perfect Order Strategy in two distinct vectors. In the first vector, we go through the overall aspects of the signals, risk assessment, and execution. We investigate each signal that the Alpha models emitted, trying to understand the reasons that provoked the Risk model to reject some of these signals or trades that passed through all the assessments, yet the broker rejected them. Furthermore, we also inspected additional data such as stop-loss placement for both approved and rejected signals.

The second vector explores the overall results that the strategy could deliver for each currency pair tested. We go through main metrics such as the gross profit, the gross loss, net return, and absolute and maximum drawdown from the account balance and equity perspective. Moreover, among other indicators, we look at the strategy's win ratio, the holding time of the positions, and consecutive wins and losses.

Lastly, before going through the back-testing results, as stated in the Methodology chapter, all seven currency pairs tested used daily data available from January 1st, 2005, to December 31st, 2020. The number of bars and ticks available for each sample may vary from pair to pair due to trading volume. Thus, in an attempt to maintain coherence and keep this text clean, the outputs of the back-testing are available in a separate **electronic supplementary repository**. The output of the back-testing for the GBP/USD pair, however, is available in **Appendix A** as an example for the reader.

### 4.1. BACK-TESTING GBP/USD

For the pair GBP/USD, the automated trading system processed 4.436 daily bars, containing the open, the low, the high, and the close prices of each trading day, and a total of 250.559.363 ticks to back-test the strategy. During this period, the alpha model emitted 56 entry signals, of which 28 were signals to open buy positions and 28 were signals to open sell positions. From the total of entry signals that the strategy generated, the risk model rejected 24 of them (42,857%). Table 4.1.1 (GBP/USD List of signals emitted by the Alpha Model) shows each date the Alpha Model triggered an entry signal.

The sole reason for these rejections was that the Risk model set *price levels* for the stop-loss limit order for these trades were above the entry price, in case of longs positions, and below the entry price, in case of shorts positions. Table 4.1.2 (GBP/USD Rejected Signals), and Figure 4.1.1 (GBP/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades) below details the rejected trades events with each entry price, stop-loss limit order prices, and distance between them. The range between the stop-loss price and entry price was 696 pips, varying from negative three pips and negative 699 pips, resulting in an average of 99,5 pips.

i	date	signal	status	Commentary	i	date	signal	status	Commentary
1	09/03/2005	buy	approved		29	10/10/2013	buy	rejected	SL rejected
2	12/07/2005	sell	approved		30	01/11/2013	buy	rejected	SL rejected

i	date	signal	status	Commentary	i	date	signal	status	Commentary
3	18/11/2005	sell	approved		31	05/12/2013	buy	approved	
4	25/05/2006	buy	rejected	SL rejected	32	06/01/2014	buy	rejected	SL rejected
5	09/08/2006	buy	approved		33	03/02/2014	buy	rejected	SL rejected Invalid Volume
6	08/09/2006	buy	rejected	SL rejected	34	25/02/2014	buy	approved	
7	15/11/2006	buy	rejected	SL rejected	35	11/04/2014	buy	approved	
8	04/12/2006	buy	approved		36	25/06/2014	buy	approved	
9	26/01/2007	buy	rejected	SL rejected	37	24/10/2014	buy	approved	
10	30/04/2007	buy	rejected	SL rejected	38	07/11/2014	sell	approved	
11	06/07/2007	buy	approved		39	25/03/2015	sell	approved	
12	19/08/2008	sell	approved		40	28/12/2015	sell	approved	
13	14/10/2008	sell	approved		41	29/02/2016	sell	approved	
14	17/12/2008	sell	rejected	SL rejected	42	13/04/2016	sell	rejected	SL rejected
15	07/01/2009	sell	rejected	SL rejected	43	15/07/2016	sell	rejected	SL rejected
16	28/01/2009	sell	rejected	SL rejected	44	15/08/2016	sell	approved	
17	17/02/2009	sell	rejected	SL rejected	45	10/10/2016	sell	approved	
18	06/04/2009	sell	rejected	SL rejected	46	10/01/2017	sell	approved	
19	20/05/2009	sell	approved		47	16/03/2017	sell	rejected	SL rejected
20	21/10/2010	buy	rejected	SL rejected	48	22/09/2017	buy	approved	
21	10/11/2010	buy	rejected	SL rejected	49	08/12/2017	buy	approved	
22	18/04/2011	buy	approved		50	09/01/2018	buy	approved	
23	12/10/2011	sell	rejected	SL rejected	51	06/04/2018	buy	rejected	SL rejected
24	09/12/2011	sell	approved		52	07/11/2018	sell	rejected	SL rejected
25	26/12/2011	sell	rejected	SL rejected	53	05/12/2018	sell	approved	
26	20/12/2012	buy	approved		54	30/07/2019	sell	approved	
27	22/03/2013	sell	approved		55	17/01/2020	buy	approved	
28	05/06/2013	sell	rejected	SL rejected	56	11/11/2020	buy	approved	

Table 4.1.1 – GBP/USD Signals emitted by the Alpha Model

Type	EP	SL	Diff.
Buy	1,8691	1,8791	-0,01000
Buy	1,8764	1,8956	-0,01920
Buy	1,8958	1,9005	-0,00470
Buy	1,9634	1,9694	-0,00600
Buy	1,9967	1,997	-0,00030
Sell	1,5577	1,4878	-0,06990
Sell	1,4905	1,4551	-0,03540
Sell	1,4152	1,4025	-0,01270
Sell	1,57839	1,57631	-0,00208
Sell	1,52658	1,50178	-0,02480
Buy	1,58395	1,58875	-0,00480
Buy	1,59809	1,60059	-0,00250
Sell	1,55901	1,54911	-0,00990
Sell	1,56266	1,55448	-0,00818
Sell	1,5315	1,51455	-0,01695
Buy	1,59529	1,6154	-0,02011
Buy	1,60434	1,61502	-0,01068

Type	EP	SL	Diff.
Buy	1,64128	1,64597	-0,00469
Buy	1,64305	1,64743	-0,00438
Sell	1,42722	1,41707	-0,01015
Sell	1,33384	1,30177	-0,03207
Sell	1,22862	1,2195	-0,00912
Buy	1,40016	1,40119	-0,00103
Sell	1,3095	1,283	-0,02650

Table 4.1.2 – GBP/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades

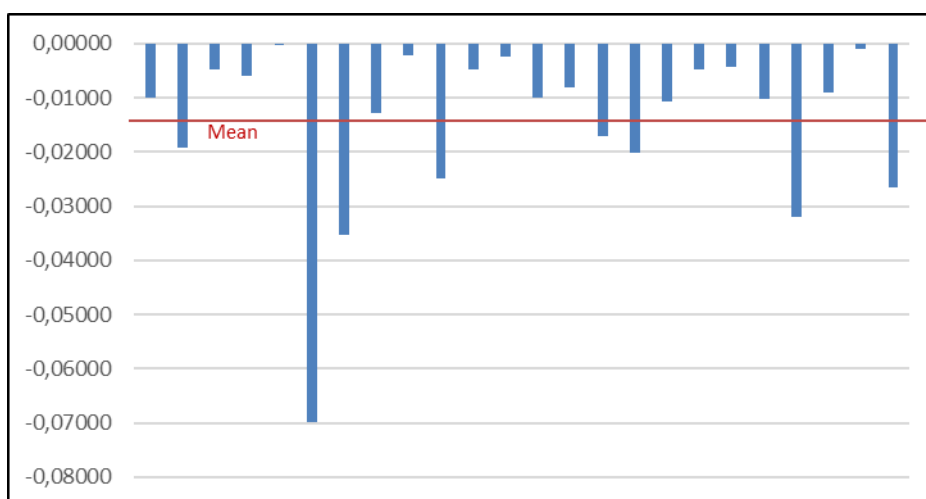


Figure 4.1.1– GBP/USD Range between Stop-loss Prices and Entry Prices of Rejected Signals

Excluded the trades in which the stop-loss limit order prices were invalid, the risk model approved 32 entry signals or 57,143% of the total signal that the strategy generated. However, because the maximum lot size allowed by the broker is 50 contracts per trade and because the risk model calculated a volume of 351,11 contracts for this particular trade, the broker rejected the trading order that the execution model filled on February 25<sup>th</sup>, 2014. We remind that the position size of a trade is the ratio between the maximum monetary risk allowed by the trading system per trade and the product of the pip value of that currency pair and the difference between the distance of the stop-loss limit order price and entry price for that particular trade, in the decimal form<sup>3</sup>.

Based on data displayed in Table 4.1.3 (GBP/USD Position Risk-Reward ratio (in pips)) below, which measures the ratio of the trading result by the risk taken in pip size for that trade, we can observe that the highest risk-reward earned was 10,99 earned per monetary unit risked, and the lowest was of negative 1,04. The average risk-reward ratio of this back-test sample was 0,24. It means that for every 1 point risked in a single trade; the automated trading system managed to profit, on average, 0,243 cents.

<sup>3</sup> See formula 1 in Item 2.6. "Position Sizing And Risk Allocation"



Type	P&L	SL Size	RR	Type	P&L	SL Size	RR
buy	- 226,30	223,00	- 1,01	sell	- 97,70	97,60	- 1,00
sell	- 46,00	46,00	- 1,00	sell	604,10	176,70	3,42
sell	- 253,80	253,00	- 1,00	sell	- 216,20	321,00	- 0,67
buy	- 192,00	335,00	- 0,57	sell	309,40	48,70	6,35
buy	- 256,00	530,00	- 0,48	sell	- 450,20	450,20	- 1,00
buy	194,00	108,00	1,80	sell	- 176,50	176,50	- 1,00
sell	82,00	506,00	0,16	sell	- 66,20	551,30	- 0,12
sell	2 726,00	248,00	10,99	sell	- 149,50	149,40	- 1,00
sell	- 5,00	466,00	- 0,01	buy	- 206,20	206,00	- 1,00
buy	- 12,10	11,80	- 1,03	buy	- 33,00	33,00	- 1,00
sell	- 101,60	101,50	- 1,00	buy	- 83,60	82,70	- 1,01
buy	- 167,20	166,90	- 1,00	sell	101,00	135,70	0,74
sell	- 5,00	4,80	- 1,04	sell	- 6,10	265,90	- 0,02
buy	- 102,70	102,60	- 1,00	buy	- 41,10	41,10	- 1,00
buy	54,00	230,20	0,23	buy	350,70	359,40	0,98
buy	54,10	64,80	0,83				

Table 4.1.3 – GBP/USD Position Reward-Risk ratio (in pips)

The strategy delivered a total of 4.475,3 pips in profits and lost 2.894 pips over the period tested. The trade that returned the highest loss was 450,2 pips, and the trade with the highest return was 2.726 pips. The data presents an average of pips earned per trade was of 51,01 and a standard deviation of 527,71. Moreover, the back-test for GBP/USD showed that from the 31 orders the execution model filled and executed, the stop-loss sizes vary from 4,8 pips to 551,3 pips. The stop-loss size samples present a mean of 209,45 pips, a standard deviation of 161,8 pips, and a range of 546,5 pips.

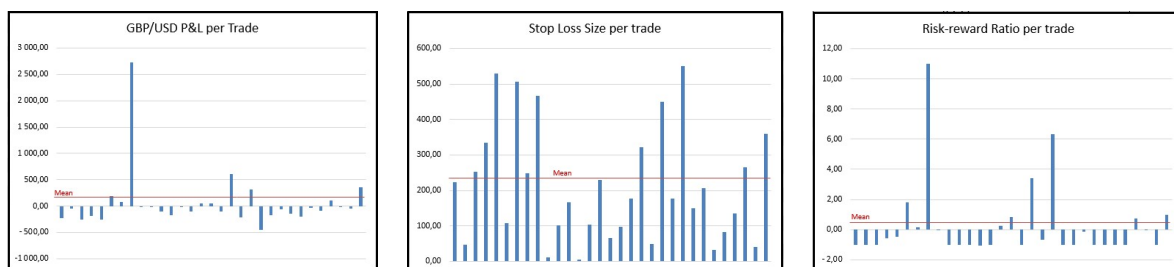


Figure 4.1.2 – GBP/USD Position Information (in pips)

According to data, the strategy generated 51.968,07\$ in gains and 39.852,1\$ in losses, resulting in a net profit of 12.115 \$, or a 12,12% return over the initial trading capital. The absolute balance drawdown of the account was 7.896,38\$, or 7,896%, while the absolute equity drawdown was 8.922,38\$ or 8.922%. Moreover, the simulation reached the maximal balance drawdown of

15.258,06\$ or 12,184%, and a maximal equity drawdown of 39.619,54, or 26,671%. One can visualize the information in Figure 4.1.3, “GBP/USD Absolute and Maximum Drawdown Balances,” below.

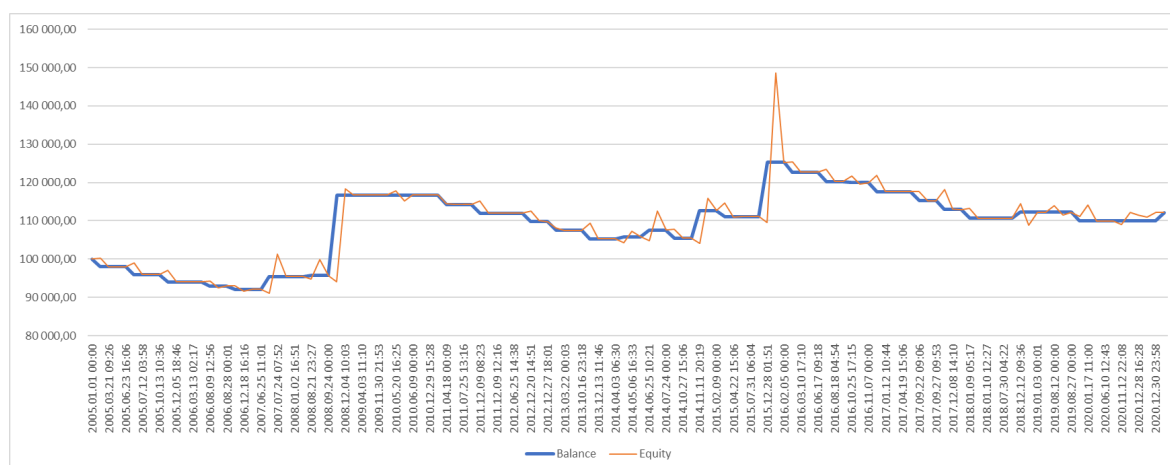


Figure 4.1.3 – GBP/USD Balance and Equity Evolution

Table 4.1.4, “GBP/USD Transactions Report”, below details each transaction that the trading system filled during the test. Of the 31 trades the algorithm executed, 17 trades were longs, and 14 were shorts. Nevertheless, nine trades resulted in profits, and the remaining 14 trades resulted in losses. The results point that the strategy had a win ratio over the back-testing period of 29%. From these losses, the stop-loss limit order that the risk module set closed 16 trades, and the position management module closed prematurely six trades due to the trend condition no longer being valid.

The most significant profit-taking in trade was 20.990,2\$, with an average profit of 5.774,23\$. The most considerable loss in trade was 2.521,12, with an average of losses of 1.811,46. The position's minimal holding time was 1.584 hours, while the minimum with the shortest duration lasted 3 minutes and 27 seconds. The average duration of the trades was of 346 hours, 24 minutes, 46 seconds. Finally, the number of consecutive trades with profit was 3, totalizing 24.618,2\$, and the number of consecutive losses was 7, totalizing 14.609,06. The complete log of the automated execution of the back-testing for the GBP/USD pair is available in **Appendix A** of this work.

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2005.01.01 00:00:00	1		balance						0,00	100 000,00	100 000,00
2005.03.09 00:01:00	2	GBPUSD	buy	in	0,9	1,93010	2	0,00	0,00	0,00	100 000,00
2005.03.21 09:27:28	3	GBPUSD	sell	out	0,9	1,90747	3	0,00	0,00	-2 036,70	97 963,30
2005.07.12 00:01:00	4	GBPUSD	sell	in	4,26	1,75770	4	0,00	0,00	0,00	97 963,30
2005.07.12 04:03:32	5	GBPUSD	buy	out	4,26	1,76230	5	0,00	0,00	-1 959,60	96 003,70
2005.11.18 00:01:00	6	GBPUSD	sell	in	0,76	1,71850	6	0,00	0,00	0,00	96 003,70
2005.12.05 18:47:40	7	GBPUSD	buy	out	0,76	1,74388	7	0,00	0,00	-1 928,88	94 074,82
2006.08.09 00:01:00	8	GBPUSD	buy	in	0,56	1,90660	8	0,00	0,00	0,00	94 074,82
2006.08.28 00:01:00	9	GBPUSD	sell	out	0,56	1,88740	9	0,00	0,00	-1 075,20	92 999,62
2006.12.04 00:00:00	10	GBPUSD	buy	in	0,35	1,98350	10	0,00	0,00	0,00	92 999,62

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2006.12.26 00:27:00	11	GBPUSD	sell	out	0,35	1,95790	11	0,00	0,00	- 896,00	92 103,62
2007.07.06 00:00:00	12	GBPUSD	buy	in	1,71	2,01170	12	0,00	0,00	0,00	92 103,62
2007.08.07 00:00:30	13	GBPUSD	sell	out	1,71	2,03110	13	0,00	0,00	3 317,40	95 421,02
2008.08.19 00:00:00	14	GBPUSD	sell	in	0,38	1,86160	14	0,00	0,00	0,00	95 421,02
2008.09.24 00:00:00	15	GBPUSD	buy	out	0,38	1,85340	15	0,00	0,00	311,60	95 732,62
2008.10.14 00:00:30	16	GBPUSD	sell	in	0,77	1,74100	16	0,00	0,00	0,00	95 732,62
2008.12.05 00:03:00	17	GBPUSD	buy	out	0,77	1,46840	17	0,00	0,00	20 990,20	116 722,82
2010.05.20 00:00:30	18	GBPUSD	sell	in	0,5	1,44500	18	0,00	0,00	0,00	116 722,82
2010.06.09 00:00:00	19	GBPUSD	buy	out	0,5	1,44550	19	0,00	0,00	- 25,00	116 697,82
2011.04.18 00:00:00	20	GBPUSD	buy	in	19,78	1,63248	20	0,00	0,00	0,00	116 697,82
2011.04.18 00:14:16	21	GBPUSD	sell	out	19,78	1,63127	21	0,00	0,00	-2 393,38	114 304,44
2011.12.09 00:00:00	22	GBPUSD	sell	in	2,25	1,56227	22	0,00	0,00	0,00	114 304,44
2011.12.09 12:16:05	23	GBPUSD	buy	out	2,25	1,57243	23	0,00	0,00	-2 286,00	112 018,44
2012.12.20 00:00:00	24	GBPUSD	buy	in	1,34	1,62514	24	0,00	0,00	0,00	112 018,44
2012.12.27 18:01:35	25	GBPUSD	sell	out	1,34	1,60842	25	0,00	0,00	-2 240,48	109 777,96
2013.03.22 00:00:00	26	GBPUSD	sell	in	45,74	1,51714	26	0,00	0,00	0,00	109 777,96
2013.03.22 00:03:27	27	GBPUSD	buy	out	45,74	1,51764	27	0,00	0,00	-2 287,00	107 490,96
2013.12.05 00:00:00	28	GBPUSD	buy	in	2,1	1,63792	28	0,00	0,00	0,00	107 490,96
2013.12.13 12:38:35	29	GBPUSD	sell	out	2,1	1,62765	29	0,00	0,00	-2 156,70	105 334,26
2014.04.11 00:00:00	30	GBPUSD	buy	in	0,92	1,67838	30	0,00	0,00	0,00	105 334,26
2014.05.21 00:00:00	31	GBPUSD	sell	out	0,92	1,68378	31	0,00	0,00	496,80	105 831,06
2014.06.25 00:00:00	32	GBPUSD	buy	in	3,27	1,69843	32	0,00	0,00	0,00	105 831,06
2014.07.24 00:00:00	33	GBPUSD	sell	out	3,27	1,70384	33	0,00	0,00	1 769,07	107 600,13
2014.10.24 00:00:00	34	GBPUSD	sell	in	2,2	1,60276	34	0,00	0,00	0,00	107 600,13
2014.10.27 15:07:19	35	GBPUSD	buy	out	2,2	1,61253	35	0,00	0,00	-2 149,40	105 450,73
2014.11.07 00:00:00	36	GBPUSD	sell	in	1,19	1,58340	36	0,00	0,00	0,00	105 450,73
2015.02.09 00:00:00	37	GBPUSD	buy	out	1,19	1,52299	37	0,00	0,00	7 188,79	112 639,52
2015.03.25 00:00:00	38	GBPUSD	sell	in	0,7	1,48438	38	0,00	0,00	0,00	112 639,52
2015.04.24 00:01:30	39	GBPUSD	buy	out	0,7	1,50600	39	0,00	0,00	-1 513,40	111 126,12
2015.12.28 00:05:00	40	GBPUSD	sell	in	4,56	1,49008	40	0,00	0,00	0,00	111 126,12
2016.02.05 00:00:00	41	GBPUSD	buy	out	4,56	1,45914	41	0,00	0,00	14 108,64	125 234,76
2016.02.29 00:00:30	42	GBPUSD	sell	in	0,56	1,38557	42	0,00	0,00	0,00	125 234,76
2016.03.10 17:58:54	43	GBPUSD	buy	out	0,56	1,43059	43	0,00	0,00	-2 521,12	122 713,64
2016.08.15 00:01:30	44	GBPUSD	sell	in	1,39	1,29195	44	0,00	0,00	0,00	122 713,64
2016.08.18 11:30:15	45	GBPUSD	buy	out	1,39	1,30960	45	0,00	0,00	-2 453,35	120 260,29
2016.10.10 00:00:00	46	GBPUSD	sell	in	0,44	1,23946	46	0,00	0,00	0,00	120 260,29
2016.11.07 00:00:30	47	GBPUSD	buy	out	0,44	1,24608	47	0,00	0,00	- 291,28	119 969,01
2017.01.10 00:00:00	48	GBPUSD	sell	in	1,61	1,21570	48	0,00	0,00	0,00	119 969,01
2017.01.12 10:45:32	49	GBPUSD	buy	out	1,61	1,23065	49	0,00	0,00	-2 406,95	117 562,06
2017.09.22 00:00:00	50	GBPUSD	buy	in	1,14	1,35868	50	0,00	0,00	0,00	117 562,06
2017.09.27 09:53:20	51	GBPUSD	sell	out	1,14	1,33806	51	0,00	0,00	-2 350,68	115 211,38
2017.12.08 00:00:00	52	GBPUSD	buy	in	6,98	1,34772	52	0,00	0,00	0,00	115 211,38
2017.12.08 14:11:19	53	GBPUSD	sell	out	6,98	1,34442	53	0,00	0,00	-2 303,40	112 907,98
2018.01.09 00:00:00	54	GBPUSD	buy	in	2,73	1,35709	54	0,00	0,00	0,00	112 907,98
2018.01.10 12:27:42	55	GBPUSD	sell	out	2,73	1,34873	55	0,00	0,00	-2 282,28	110 625,70
2018.12.05 00:02:00	56	GBPUSD	sell	in	1,63	1,27111	56	0,00	0,00	0,00	110 625,70
2019.01.03 00:01:30	57	GBPUSD	buy	out	1,63	1,26101	57	0,00	0,00	1 646,30	112 272,00
2019.07.30 00:00:00	58	GBPUSD	sell	in	0,84	1,22152	58	0,00	0,00	0,00	112 272,00
2019.08.27 00:00:00	59	GBPUSD	buy	out	0,84	1,22213	59	0,00	0,00	- 51,24	112 220,76
2020.01.17 00:00:00	60	GBPUSD	buy	in	5,46	1,30832	60	0,00	0,00	0,00	112 220,76
2020.01.17 11:00:14	61	GBPUSD	sell	out	5,46	1,30421	61	0,00	0,00	-2 244,06	109 976,70
2020.11.11 00:00:00	62	GBPUSD	buy	in	0,61	1,32729	62	0,00	0,00	0,00	109 976,70
2020.12.30 23:59:59	63	GBPUSD	sell	out	0,61	1,36236	63	0,00	0,00	2 139,27	112 115,97

Table 4.1.4 – GBP/USD Transactions Report

## 4.2. BACK-TESTING EUR/USD

When running the strategy on the EUR/USD pair, the trading system processed 4.144 daily bars, containing the open, the low, the high, and the close prices of each trading day, and a total of 243.396.744 ticks. During this period, the alpha model emitted 52 entry signals, of which 25 were signals to open buy positions and 27 were signals to open sell positions.

From the total of signals that the model triggered, the risk model rejected 16 of them or 30.8% of the total, and the broker rejected three trades the execution model filled because the lot size set by the risk model was higher than the 50 lots allowed per trade, on 2008/07/08 an order filled with 68,43 contracts, on 2015/10/19 an order filled with 46,46 contracts, and on 2019/02/20 an order filled with 155,44 contracts. Table 4.2.1 (EUR/USD Signals Triggered by the Alpha Model) details the dates of each triggered signal and whether the risk model accepted or rejected these signals.

i	date	signal	status	Commentary	i	date	signal	status	Commentary
1	21/06/2005	sell	rejected	SL rejected	27	25/09/2013	buy	approved	
2	14/11/2005	sell	approved		28	19/12/2013	buy	rejected	SL rejected
3	09/05/2006	buy	approved		29	18/08/2014	sell	approved	
4	07/12/2006	buy	approved		30	06/11/2014	sell	approved	
5	02/03/2007	buy	approved		31	05/03/2015	sell	approved	
6	23/03/2007	buy	approved		32	17/04/2015	sell	rejected	SL rejected
7	17/07/2007	buy	approved		33	19/10/2015	buy	approved	Invalid Volume
8	25/09/2007	buy	approved		34	10/05/2016	buy	rejected	SL rejected
9	08/02/2008	buy	rejected	SL rejected	35	04/11/2016	sell	rejected	SL rejected
10	03/03/2008	buy	approved		36	23/11/2016	sell	approved	
11	08/07/2008	buy	approved	Invalid Volume	37	23/12/2016	sell	approved	
12	13/10/2008	sell	approved		38	10/03/2017	sell	approved	
13	05/02/2009	sell	approved		39	06/07/2017	buy	rejected	SL rejected
14	08/07/2009	buy	rejected	SL rejected	40	04/09/2017	buy	rejected	SL rejected
15	27/07/2009	buy	approved		41	22/01/2018	buy	approved	
16	20/10/2009	buy	approved		42	13/08/2018	sell	approved	
17	01/04/2010	sell	rejected	SL rejected	43	26/10/2018	sell	approved	
18	04/05/2010	sell	approved		44	20/02/2019	sell	approved	Invalid Volume
19	15/11/2010	buy	rejected	SL rejected	45	18/03/2019	sell	rejected	SL rejected
20	14/03/2011	buy	rejected	SL rejected	46	09/04/2019	sell	rejected	SL rejected
21	01/12/2011	sell	rejected	SL rejected	47	16/05/2019	sell	approved	
22	31/05/2012	sell	approved		48	01/08/2019	sell	approved	
23	10/07/2012	sell	approved		49	28/08/2019	sell	approved	
24	21/12/2012	buy	approved		50	03/10/2019	sell	approved	
25	24/01/2013	buy	approved		51	27/02/2020	sell	rejected	SL rejected
26	25/09/2013	buy	approved		52	22/07/2020	buy	approved	
27	19/12/2013	buy	rejected	SL rejected	53	20/11/2020	buy	approved	

Table 4.2.1 – EUR/USD Signals Triggered by the Alpha Model

Table 4.2.2 (EUR/USD Stop-loss Placement of the Rejected Trades) details the rejected trades events with each entry price, the stop-loss limit order prices, and the distance between them. The main reason for these rejections was that the prices that the strategy set for the stop-loss limit order for the trades were above entry price, in case of long positions, and below the entry price, in case of short positions. The distance between the stop-loss price and entry price was 290 pips, varying from negative one pip and negative 291 pips, with a mean at 99,5 pips. See Figure 4.2.1 (Distribution of EUR/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades).

Type	EP	SL	Diff.
Sell	1,2155	1,2154	-0,00010
Buy	1,4495	1,4786	-0,02910
Buy	1,39218	1,40009	-0,00791
Sell	1,35065	1,33861	-0,01204
Buy	1,36846	1,38874	-0,02028
Buy	1,39524	1,3955	-0,00026
Sell	1,34392	1,34109	-0,00283
Buy	1,36754	1,37376	-0,00622
Sell	1,07592	1,06833	-0,00759
Buy	1,13864	1,14947	-0,01083
Sell	1,11052	1,09915	-0,01137
Buy	1,13521	1,13741	-0,00220
Buy	1,18869	1,19166	-0,00297
Sell	1,13244	1,12584	-0,00660
Sell	1,12601	1,12158	-0,00443
Sell	1,08816	1,08202	-0,00614

Table 4.2.2 – EUR/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades

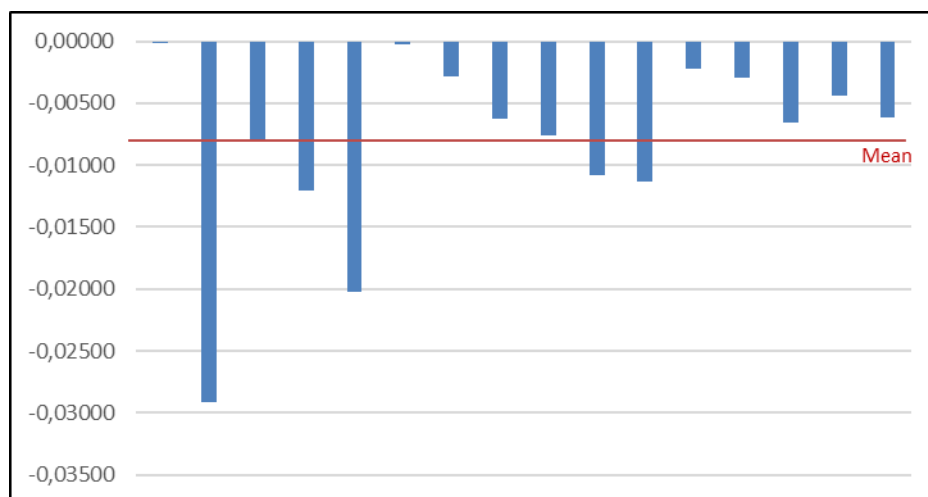


Figure 4.2.1– Distribution of EUR/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades

From Table 4.2.3 – EUR/USD Position Risk-Reward ratio (in pips) below, one can observe that the highest risk-reward earned was 37,59 earned per monetary unit risked, and the lowest was of negative 1,42. The average risk-reward ratio of this back-test sample was 1,20. It means that the automated trading system managed to profit, on average, 1,2 points for every 1 point risked in a single trade.

i	Type	P&L	SL Size	RR	i	Type	P&L	SL Size	RR
1	sell	-116	116	-1,00	17	buy	37,2	41,6	0,89
2	buy	-53	149	-0,36	18	buy	-133,4	133	-1,00
3	buy	-142,8	142	-1,01	19	sell	635,2	16,9	37,59
4	buy	-79	79	-1,00	20	sell	-33,1	164,2	-0,20
5	buy	151	88	1,72	21	sell	243,6	301,9	0,81
6	buy	-76	183	-0,42	22	sell	-137,2	137,2	-1,00
7	buy	639	253	2,53	23	sell	-42,9	41,2	-1,04
8	buy	405	420	0,96	24	sell	-49,9	49,9	-1,00
9	sell	-107,1	107	-1,00	25	buy	233,4	85,3	2,74
10	sell	-138	343	-0,40	26	sell	-200,2	199,4	-1,00
11	buy	-122,7	122,7	-1,00	27	sell	78,6	161,1	0,49
12	buy	-205,7	205,4	-1,00	28	sell	-65,6	50,3	-1,30
13	sell	862,9	224,6	3,84	29	sell	-118,4	118,4	-1,00
14	sell	-251,2	251,2	-1,00	30	sell	-24,3	17,1	-1,42
15	sell	-85,6	312,2	-0,27	31	sell	-7,8	7,8	-1,00
16	buy	-181,8	181,7	-1,00	32	buy	306,1	138,9	2,20
17	buy	37,2	41,6	0,89	33	buy	418,2	79	5,29

Table 4.2.3 – EUR/USD Position Risk-Reward ratio (in pips)

The strategy delivered a total of 4.010,2 pips in profits and lost 2.371,7 pips over the period tested. The trade that returned the highest loss was 251,2 pips, and the trade with the highest return was 862,9 pips. The average of pips earned per trade was 49,65 and a standard deviation of 269.28. Moreover, the back-test for GBP/USD showed that from the 33 orders the execution model filled and executed, the stop-loss sizes vary from 7,8 pips to 420 pips. The stop-loss size samples present a mean of 149.12 pips, a standard deviation of 97.93 pips, and a range of 412,2 pips. Graph 4.2.2 (EUR/USD Position Information in pips) shows all details below.

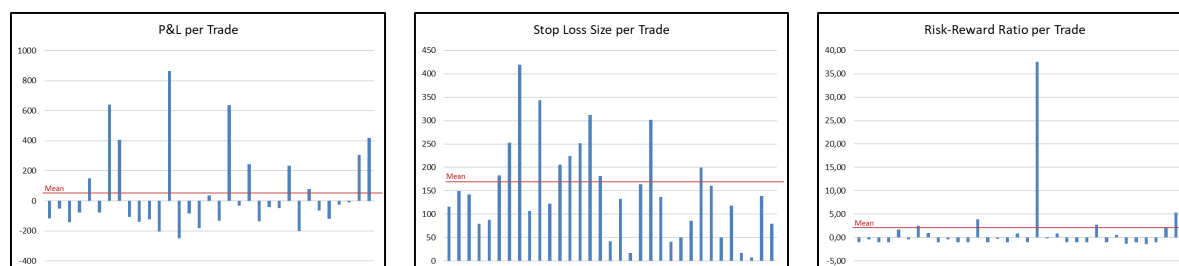
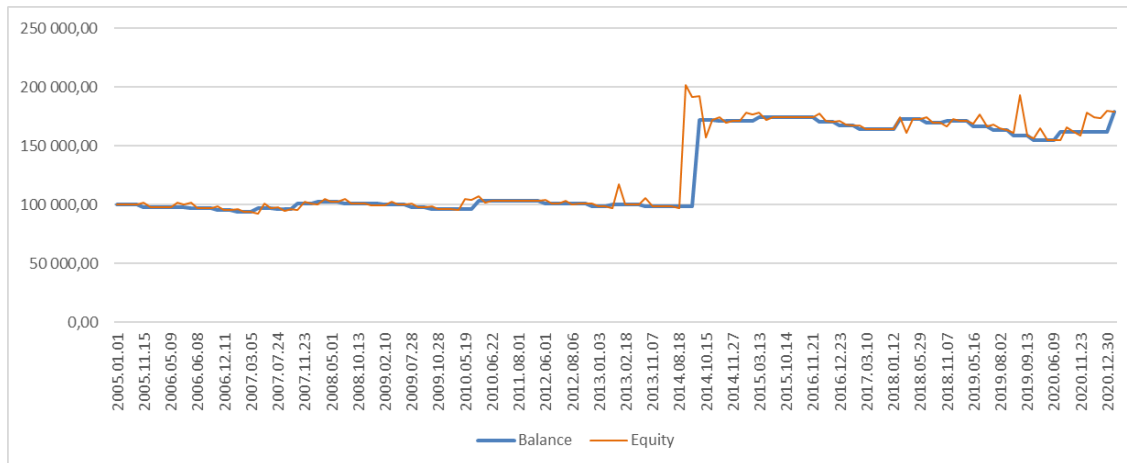


Figure 4.2.2 – EUR/USD Position Information (in pips)

The strategy generated 130.293,9\$ in gains and 51.503,87 \$ in losses, resulting in a net profit of 78.790,03\$, or 78,79% return over the initial trading capital. The absolute balance drawdown of the account was 6.555,06 \$, or 6,56%, while the absolute equity drawdown was 8.102,66 \$ or 8,1%. Moreover, the simulation reached the maximal balance drawdown of 19.361,71\$ or 11,11%, and a maximal equity drawdown of 47.464,47, or 23,52%. One can visualize the information in Graph 4.2.3 (EUR/USD Balance and Equity Evolution below).



Graph 4.2.1 - EUR/USD Balance and Equity Evolution

Table 4.2.4 (EUR/USD Transactions Report) details each trading system's transaction accomplished during the test. Of the 33 trades that the algorithm executed, 15 trades were longs, and 18 were shorts. Nevertheless, 11 trades resulted in profits, and the remaining 22 trades resulted in losses. From these losses, the stop-loss limit order that the risk module set closed 19 trades, and the position management module closed prematurely three trades due to the trend condition no longer being valid. This result shows that the strategy had a win ratio over the back-testing period of 33,3%.

The most significant profit-taking in trade was 73.873,76 \$, with an average profit of 11.844,9 \$. The most considerable loss in trade was 4.553,82\$, with an average of losses of 2.341,09 \$. The position's maximal holding time was 1320 hours, while the trade with the minimal holding duration lasted less than a second. The average duration of the trades was 411 hours, 2 minutes, 28 seconds. Finally, the number of consecutive trades with profit in the test was 2, totalizing 23.930,41 \$, and the number of consecutive losses was 4, totalizing 16.126,82. The complete log of the automated execution of the back-testing is available in **Appendix B** of the electronic supplementary repository of this work.

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2005.01.01 00:00:00	1		balance						0,00	0,00	100 000,00
2005.11.14 00:01:00	2	EURUSD	sell	in	1,72	1,17180	2	0,00	0,00	0,00	100 000,00
2005.11.21 10:11:18	3	EURUSD	buy	out	1,72	1,18340	3	0,00	0,00	-1 995,20	98 004,80
2006.05.09 00:01:00	4	EURUSD	buy	in	1,32	1,27060	4	0,00	0,00	0,00	98 004,80
2006.06.09 00:01:00	5	EURUSD	sell	out	1,32	1,26530	5	0,00	0,00	- 699,60	97 305,20
2006.12.07 00:00:00	6	EURUSD	buy	in	1,37	1,32820	6	0,00	0,00	0,00	97 305,20

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2006.12.11 03:09:29	7	EURUSD	sell	out	1,37	1,31392	7	0,00	0,00	-1 956,36	95 348,84
2007.03.02 00:00:00	8	EURUSD	buy	in	2,41	1,31800	8	0,00	0,00	0,00	95 348,84
2007.03.05 12:33:59	9	EURUSD	sell	out	2,41	1,31010	9	0,00	0,00	-1 903,90	93 444,94
2007.03.23 00:00:30	10	EURUSD	buy	in	2,12	1,33260	10	0,00	0,00	0,00	93 444,94
2007.05.11 00:00:00	11	EURUSD	sell	out	2,12	1,34770	11	0,00	0,00	3 201,20	96 646,14
2007.07.17 00:00:00	12	EURUSD	buy	in	1,06	1,37770	12	0,00	0,00	0,00	96 646,14
2007.08.03 00:00:00	13	EURUSD	sell	out	1,06	1,37010	13	0,00	0,00	- 805,60	95 840,54
2007.09.25 00:00:30	14	EURUSD	buy	in	0,76	1,40810	14	0,00	0,00	0,00	95 840,54
2007.12.11 00:01:00	15	EURUSD	sell	out	0,76	1,47200	15	0,00	0,00	4 856,40	100 696,94
2008.03.03 00:04:00	16	EURUSD	buy	in	0,48	1,52140	16	0,00	0,00	0,00	100 696,94
2008.05.01 00:01:30	17	EURUSD	sell	out	0,48	1,56190	17	0,00	0,00	1 944,00	102 640,94
2008.10.13 00:00:30	18	EURUSD	sell	in	1,92	1,35710	18	0,00	0,00	0,00	102 640,94
2008.10.13 15:05:52	19	EURUSD	buy	out	1,92	1,36781	19	0,00	0,00	-2 056,32	100 584,62
2009.02.05 00:00:00	20	EURUSD	sell	in	0,59	1,28340	20	0,00	0,00	0,00	100 584,62
2009.03.17 00:01:00	21	EURUSD	buy	out	0,59	1,29720	21	0,00	0,00	- 814,20	99 770,42
2009.07.27 00:00:00	22	EURUSD	buy	in	1,63	1,42317	22	0,00	0,00	0,00	99 770,42
2009.07.29 13:30:14	23	EURUSD	sell	out	1,63	1,41090	23	0,00	0,00	-2 000,01	97 770,41
2009.10.20 00:00:00	24	EURUSD	buy	in	0,95	1,49662	24	0,00	0,00	0,00	97 770,41
2009.10.28 12:30:27	25	EURUSD	sell	out	0,95	1,47605	25	0,00	0,00	-1 954,15	95 816,26
2010.05.04 00:00:00	26	EURUSD	sell	in	0,85	1,31884	26	0,00	0,00	0,00	95 816,26
2010.06.22 00:00:00	27	EURUSD	buy	out	0,85	1,23255	27	0,00	0,00	7 334,65	103 150,91
2012.05.31 00:00:00	28	EURUSD	sell	in	0,82	1,23676	28	0,00	0,00	0,00	103 150,91
2012.06.07 15:25:25	29	EURUSD	buy	out	0,82	1,26188	29	0,00	0,00	-2 059,84	101 091,07
2012.07.10 00:00:00	30	EURUSD	sell	in	0,65	1,23135	30	0,00	0,00	0,00	101 091,07
2012.08.07 00:00:00	31	EURUSD	buy	out	0,65	1,23991	31	0,00	0,00	- 556,40	100 534,67
2012.12.21 00:00:00	32	EURUSD	buy	in	1,11	1,32474	32	0,00	0,00	0,00	100 534,67
2013.01.03 20:08:15	33	EURUSD	sell	out	1,11	1,30656	33	0,00	0,00	-2 017,98	98 516,69
2013.01.24 00:00:00	34	EURUSD	buy	in	4,74	1,33112	34	0,00	0,00	0,00	98 516,69
2013.02.18 00:00:00	35	EURUSD	sell	out	4,74	1,33484	35	0,00	0,00	1 763,28	100 279,97
2013.09.25 00:00:00	36	EURUSD	buy	in	1,51	1,34710	36	0,00	0,00	0,00	100 279,97
2013.11.07 14:30:35	37	EURUSD	sell	out	1,51	1,33376	37	0,00	0,00	-2 014,34	98 265,63
2014.08.18 00:00:00	38	EURUSD	sell	in	11,63	1,33913	38	0,00	0,00	0,00	98 265,63
2014.10.20 00:00:00	39	EURUSD	buy	out	11,63	1,27561	39	0,00	0,00	73 873,76	172 139,39
2014.11.06 00:00:00	40	EURUSD	sell	in	2,1	1,24746	40	0,00	0,00	0,00	172 139,39
2014.11.27 00:00:00	41	EURUSD	buy	out	2,1	1,25077	41	0,00	0,00	- 695,10	171 444,29
2015.03.05 00:01:00	42	EURUSD	sell	in	1,14	1,10772	42	0,00	0,00	0,00	171 444,29
2015.03.31 00:00:00	43	EURUSD	buy	out	1,14	1,08336	43	0,00	0,00	2 777,04	174 221,33
2016.11.23 00:00:00	44	EURUSD	sell	in	2,54	1,06220	44	0,00	0,00	0,00	174 221,33
2016.12.05 19:51:29	45	EURUSD	buy	out	2,54	1,07592	45	0,00	0,00	-3 484,88	170 736,45
2016.12.23 00:00:00	46	EURUSD	sell	in	8,29	1,04326	46	0,00	0,00	0,00	170 736,45
2016.12.23 23:59:59	47	EURUSD	buy	out	8,29	1,04755	47	0,00	0,00	-3 556,41	167 180,04
2017.03.10 00:00:00	48	EURUSD	sell	in	6,7	1,05737	48	0,00	0,00	0,00	167 180,04
2017.03.10 15:31:54	49	EURUSD	buy	out	6,7	1,06236	49	0,00	0,00	-3 343,30	163 836,74
2018.01.22 00:00:00	50	EURUSD	buy	in	3,84	1,22728	50	0,00	0,00	0,00	163 836,74
2018.02.16 00:00:00	51	EURUSD	sell	out	3,84	1,25062	51	0,00	0,00	8 962,56	172 799,30
2018.08.13 00:01:00	52	EURUSD	sell	in	1,73	1,13714	52	0,00	0,00	0,00	172 799,30
2018.08.21 19:56:05	53	EURUSD	buy	out	1,73	1,15716	53	0,00	0,00	-3 463,46	169 335,84
2018.10.26 00:00:00	54	EURUSD	sell	in	2,1	1,13731	54	0,00	0,00	0,00	169 335,84
2018.11.28 00:01:30	55	EURUSD	buy	out	2,1	1,12945	55	0,00	0,00	1 650,60	170 986,44
2019.05.16 00:00:00	56	EURUSD	sell	in	6,72	1,12005	56	0,00	0,00	0,00	170 986,44
2019.06.03 00:00:02	57	EURUSD	buy	out	6,72	1,12661	57	0,00	0,00	-4 408,32	166 578,12
2019.08.01 00:00:00	58	EURUSD	sell	in	2,98	1,10686	58	0,00	0,00	0,00	166 578,12
2019.08.05 00:00:01	59	EURUSD	buy	out	2,98	1,11870	59	0,00	0,00	-3 528,32	163 049,80
2019.08.28 00:00:00	60	EURUSD	sell	in	18,74	1,10893	60	0,00	0,00	0,00	163 049,80
2019.09.13 00:00:02	61	EURUSD	buy	out	18,74	1,11136	61	0,00	0,00	-4 553,82	158 495,98
2019.10.03 00:00:00	62	EURUSD	sell	in	46,62	1,09588	62	0,00	0,00	0,00	158 495,98
2019.10.03 00:00:01	63	EURUSD	buy	out	46,62	1,09666	63	0,00	0,00	-3 636,36	154 859,62
2020.07.22 00:00:00	64	EURUSD	buy	in	2,23	1,15277	64	0,00	0,00	0,00	154 859,62
2020.09.14 00:00:00	65	EURUSD	sell	out	2,23	1,18338	65	0,00	0,00	6 826,03	161 685,65
2020.11.20 00:00:00	66	EURUSD	buy	in	4,09	1,18757	66	0,00	0,00	0,00	161 685,65
2020.12.30 23:59:59	67	EURUSD	sell	out	4,09	1,22939	67	0,00	0,00	17 104,38	178 790,03



Table 4.2.4 – EUR/USD Transactions Report

### 4.3. BACK-TESTING AUD/USD

For the back-testing of EUR/USD pair, the trading system processed 4.144 daily bars, containing the open, the low, the high, and the close prices of each trading day, and a total of 208.478.112 ticks. During this period, the alpha model emitted 60 entry signals, of which 30 signals were to open buy positions and 30 signals were to open sell positions. From the total of signals that the model triggered, the risk model rejected 20 of them or 33,3% of the total, and the broker rejected two trades due to the stop-loss size being higher than the limit authorized – i.e., on 2013/08/08, a trade filled with 1904,4 contracts, and on 2019/05/13 a trade filled with 51,47 contracts. Table 4.3.1 (AUD/USD Signals Triggered by the Alpha Model) details the dates each signal was triggered. It also shows if the risk model accepted or rejected the signals and the reasons for it.

i	date	signal	status	Commentary	i	date	signal	status	Commentary
1	26/10/2005	sell	rejected	SL rejected	31	13/05/2013	sell	approved	
2	31/03/2006	sell	rejected	SL rejected	32	08/08/2013	sell	approved	Invalid Volume
3	01/08/2006	buy	approved		33	05/09/2013	sell	rejected	SL rejected
4	12/09/2006	buy	rejected	SL rejected	34	27/01/2014	sell	approved	
5	08/11/2006	buy	rejected	SL rejected	35	26/06/2014	buy	approved	
6	04/12/2006	buy	approved		36	13/11/2014	sell	rejected	SL rejected
7	08/01/2007	buy	rejected	SL rejected	37	02/02/2015	sell	approved	
8	27/03/2007	buy	approved		38	17/03/2015	sell	approved	
9	13/06/2007	buy	approved		39	14/04/2015	sell	approved	
10	31/10/2007	buy	approved		40	21/07/2015	sell	approved	
11	07/03/2008	buy	rejected	SL rejected	41	31/08/2015	sell	approved	
12	25/04/2008	buy	approved		42	08/10/2015	sell	rejected	SL rejected
13	04/07/2008	buy	approved		43	12/04/2016	buy	approved	
14	13/10/2008	sell	approved		44	17/08/2016	buy	approved	
15	25/11/2008	sell	approved		45	26/07/2017	buy	approved	
16	09/02/2009	sell	rejected	SL rejected	46	08/02/2018	buy	rejected	SL rejected
17	17/06/2009	buy	rejected	SL rejected	47	03/05/2018	sell	approved	
18	29/07/2009	buy	approved		48	25/06/2018	sell	approved	
19	20/11/2009	buy	rejected	SL rejected	49	15/08/2018	sell	approved	
20	22/04/2009	buy	rejected	SL rejected	50	12/10/2018	sell	rejected	SL rejected
21	11/06/2010	sell	rejected	SL rejected	51	04/01/2019	sell	approved	
22	25/10/2010	buy	approved		52	13/03/2019	sell	approved	
23	10/11/2010	buy	approved		53	13/05/2019	sell	approved	Invalid Volume
24	03/01/2011	buy	approved		54	26/06/2019	sell	rejected	SL rejected
25	08/02/2011	buy	approved		55	12/08/2019	sell	approved	
26	06/04/2011	buy	approved		56	16/10/2019	sell	rejected	SL rejected
27	07/12/2011	sell	approved		57	02/03/2020	sell	approved	
28	28/12/2011	sell	approved		58	19/08/2020	buy	approved	
29	27/12/2012	buy	rejected	SL rejected	59	24/11/2020	buy	rejected	SL rejected
30	17/01/2013	buy	approved		60	10/12/2020	buy	approved	

Table 4.3.1– AUD/USD Signals Triggered by the Alpha Model

Table 4.3.2 (AUD/USD Stop-loss Placement of the Rejected Trades) details the rejected trades events with each entry price, the stop-loss limit order prices, and the distance between them. The main reason for these rejections, as seen in table 4.3.1, was that the prices that the strategy set for the stop-loss limit order for these trades were above entry price, in case of longs positions, and below the entry price in case of short positions. The range between the stop-loss price and entry price was 354 pips, varying from 0 pip and negative 354 pips, with a mean at 43,1 pips. See Graph 4.3.1 (Distribution of AUD/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades).

Type	EP	SL	Diff.
Sell	0,7564	0,7515	-0,0049
Sell	0,7146	0,7136	-0,001
Buy	0,7514	0,7683	-0,0169
Buy	0,7729	0,7729	0
Buy	0,7792	0,7852	-0,006
Buy	0,9268	0,9303	-0,0035
Sell	0,672	0,6366	-0,0354
Buy	0,79233	0,79666	-0,00433
Buy	0,91941	0,92342	-0,00401
Buy	0,92688	0,93101	-0,00413
Sell	0,84845	0,8476	-0,00085
Buy	1,0374	1,04722	-0,00982
Sell	0,91623	0,89783	-0,0184
Sell	0,8709	0,86268	-0,00822
Sell	0,72047	0,70844	-0,01203
Buy	0,78247	0,79874	-0,01627
Sell	0,71213	0,70864	-0,00349
Sell	0,69514	0,69085	-0,00429
Sell	0,67516	0,67491	-0,00025
Buy	0,72871	0,72882	-0,00011

Table 4.3.2– AUD/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades

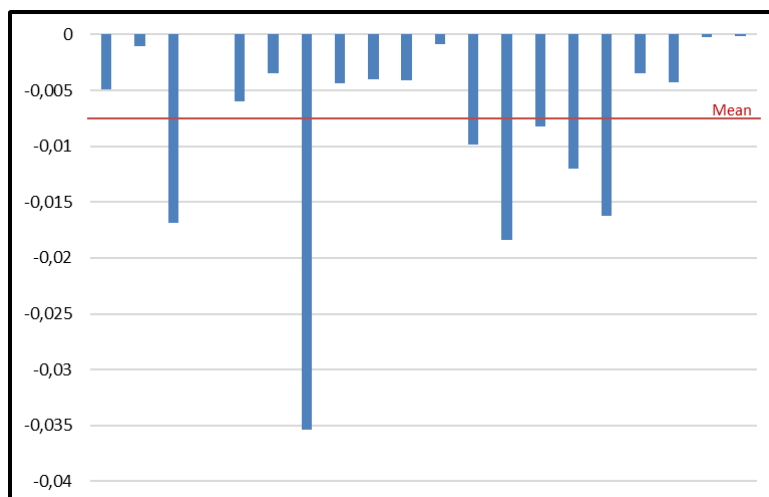


Figure 4.3.1 – AUD/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades

From Table 4.3.3 (AUD/USD Position Risk-Reward ratio (in pips)) below, one can observe that the highest risk-reward earned was 4,96 earned per monetary unit risked, and the lowest was negative 1.02. The automated trading system lost, on average, 0.29 points for every 1 point risked in a single trade.

Type	P&L	SL Size	RR	Type	P&L	SL Size	RR
sell	-29	139	- 0,21	buy	-131,4	131,4	-1,00
sell	-68	147	- 0,46	sell	-13	13	-1,00
sell	108	140	0,77	buy	-130,8	178,2	-0,73
sell	-37	37	- 1,00	buy	-67,2	66,1	-1,02
sell	-268,7	268	- 1,00	buy	-122,2	122,1	-1,00
sell	88	121	0,73	buy	4,1	110	0,04
sell	-60,1	60	- 1,00	buy	-39,2	160,7	-0,24
buy	71	925	0,08	sell	-87,9	87,8	-1,00
buy	-26,1	26	- 1,00	sell	-36,4	36,4	-1,00
sell	111,6	167	0,67	sell	-31,9	31,8	-1,00
sell	-51,2	50,5	- 1,01	buy	-97,2	97,2	-1,00
sell	-128,9	128,9	- 1,00	buy	-16	15,9	-1,01
sell	-239,3	239,3	- 1,00	buy	-15	199,5	-0,08
sell	-172,9	172,8	- 1,00	buy	-75,9	75,9	-1,00
sell	243,5	55,2	4,41	buy	-11,9	11,9	-1,00
buy	-54	89,5	- 0,60	buy	-23	23	-1,00
buy	-75,4	75,3	- 1,00	buy	-155,6	154,8	-1,01
sell	-72,9	72,8	- 1,00	sell	43,4	134,1	0,32
buy	762	299	2,55	sell	238,9	48,2	4,96

Table 4.3.3– AUD/USD Position Risk-Reward ratio (in pips)

The strategy delivered a total of 1.670,5 pips in profits and 2.338,1 pips in losses over the period tested, resulting in a net return of negative 667,6 pips. The trade that returned the highest loss was

268.7 pips, and the trade with the highest return was 762 pips. The average of pips lost per trade was 17,568 and a standard deviation of 164,95 pips. Moreover, the back-test for AUD/USD showed that from the 40 orders the execution model filled and executed, the stop-loss sizes vary from 11.9 pips to 925 pips. The stop-loss size samples present a mean of 103.6 pips, a standard deviation of 148.3 pips, and a range of 913.1 pips. See Figure 4.3.2 (AUD/USD Position Information (in pips)).

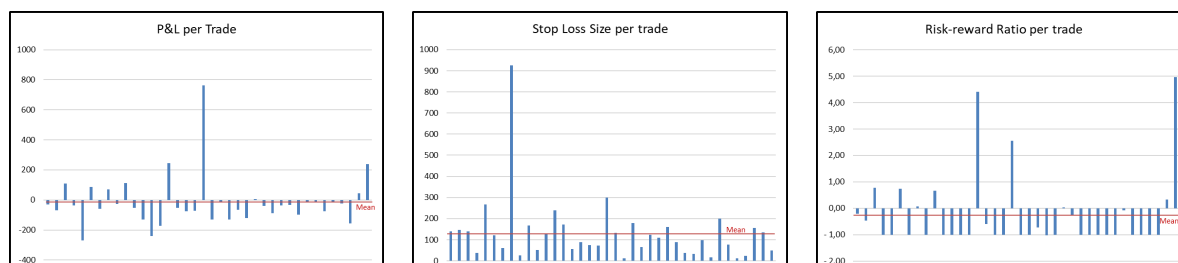


Figure 4.3.2 – AUD/USD Position Information (in pips)

The strategy generated 24.408,27 \$ in gains and 45.047,71 \$ in losses, resulting in a net loss of 20.639,44 \$ or a negative 20,6% return over the initial trading capital. The absolute balance drawdown of the account was 28.270,82 \$, or 28,3%, while the absolute equity drawdown was 29,421,07 \$ or 29,4%. Moreover, the simulation reached the maximal balance drawdown of 28.458,02 \$ or 28,4%, and a maximal equity drawdown of 41.081,91 or 36,8%. The information is available on Figure 4.3.3 (AUD/USD Balance and Equity Evolution) below.

Table 4.3.4 (AUD/USD Transactions Report) below details each transaction the trading system accomplished during the test. Of the 38 trades that the algorithm executed, 20 trades were longs, and 18 were shorts. However, nine trades resulted in profits, and the remaining 29 trades resulted in losses. From these losses, the stop-loss limit order that the risk module set closed 19 trades, and the position management module closed prematurely six trades due to the trend condition no longer being valid. This result shows that the strategy had a win ratio over the back-testing period of 23,7%.

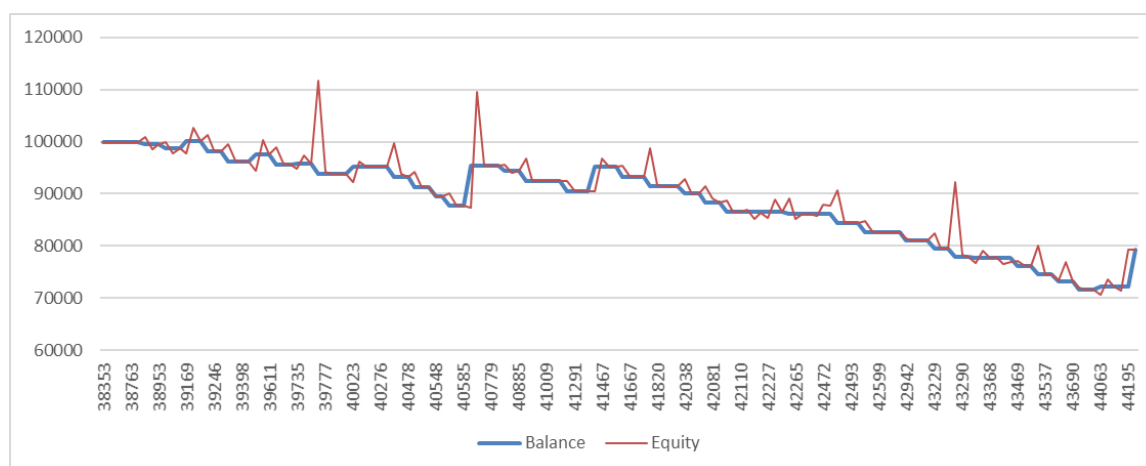


Figure 4.3.3– AUD/USD Balance and Equity Evolution

The maximal holding time of a position was of 1.224 hours, while the trade with the minimal holding duration of 4:15:29. The average duration of the trades was 258:26:17. The largest loss in trade was 2.005,4 \$, with an average loss of 1.553,37\$. The most considerable profit taken in trade was 7.743,3\$, with an average profit of 2.712,03\$. Finally, the number of consecutive trades with profit in the test was 2, totalizing 7.631.38\$, and the number of consecutive losses was 11, totalizing negative 14.832,05\$. See **Appendix C** of the supplementary electronic repository of this work for the complete output of the back-testing.

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2005.01.01 00:00:00	1		balance						0,00	100 000,00	100 000,00
2006.08.01 00:02:00	2	AUDUSD	buy	in	1.44	0,76570	2	0,00	0,00	0,00	100 000,00
2006.08.24 00:01:00	3	AUDUSD	sell	out	1.44	0,76280	3	0,00	0,00	- 417,60	99 582,40
2006.12.04 00:00:00	4	AUDUSD	buy	in	1.35	0,79080	4	0,00	0,00	0,00	99 582,40
2006.12.22 00:00:00	5	AUDUSD	sell	out	1.35	0,78400	5	0,00	0,00	- 918,00	98 664,40
2007.03.27 00:02:30	6	AUDUSD	buy	in	1.41	0,81020	6	0,00	0,00	0,00	98 664,40
2007.05.07 00:00:30	7	AUDUSD	sell	out	1.41	0,82100	7	0,00	0,00	1 522,80	100 187,20
2007.06.13 00:04:30	8	AUDUSD	buy	in	5.42	0,84050	8	0,00	0,00	0,00	100 187,20
2007.06.13 11:59:59	9	AUDUSD	sell	out	5.42	0,83680	9	0,00	0,00	-2 005,40	98 181,80
2007.10.31 00:00:00	10	AUDUSD	buy	in	0.73	0,92030	10	0,00	0,00	0,00	98 181,80
2007.11.12 04:37:32	11	AUDUSD	sell	out	0.73	0,89343	11	0,00	0,00	-1 961,51	96 220,29
2008.04.25 00:00:30	12	AUDUSD	buy	in	1.59	0,93920	12	0,00	0,00	0,00	96 220,29
2008.06.12 00:01:30	13	AUDUSD	sell	out	1.59	0,94800	13	0,00	0,00	1 399,20	97 619,49
2008.07.04 00:09:00	14	AUDUSD	buy	in	3.25	0,96010	14	0,00	0,00	0,00	97 619,49
2008.07.07 15:18:34	15	AUDUSD	sell	out	3.25	0,95409	15	0,00	0,00	-1 953,25	95 666,24
2008.10.13 00:00:00	16	AUDUSD	sell	in	0.21	0,67940	16	0,00	0,00	0,00	95 666,24
2008.11.11 00:00:30	17	AUDUSD	buy	out	0.21	0,67230	17	0,00	0,00	149,10	95 815,34
2008.11.25 00:00:30	18	AUDUSD	sell	in	7.37	0,65500	18	0,00	0,00	0,00	95 815,34
2008.11.25 15:14:49	19	AUDUSD	buy	out	7.37	0,65761	19	0,00	0,00	-1 923,57	93 891,77
2009.07.29 00:00:00	20	AUDUSD	buy	in	1.12	0,82659	20	0,00	0,00	0,00	93 891,77
2009.08.24 00:00:00	21	AUDUSD	sell	out	1.12	0,83775	21	0,00	0,00	1 249,92	95 141,69
2010.10.25 00:00:00	22	AUDUSD	buy	in	3.77	0,98509	22	0,00	0,00	0,00	95 141,69
2010.10.27 02:30:38	23	AUDUSD	sell	out	3.77	0,97997	23	0,00	0,00	-1 930,24	93 211,45
2010.11.10 00:00:00	24	AUDUSD	buy	in	1.45	1,00257	24	0,00	0,00	0,00	93 211,45
2010.11.12 07:04:38	25	AUDUSD	sell	out	1.45	0,98968	25	0,00	0,00	-1 869,05	91 342,40
2011.01.03 00:00:00	26	AUDUSD	buy	in	0.76	1,02260	26	0,00	0,00	0,00	91 342,40

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2011.01.05 13:51:36	27	AUDUSD	sell	out	0.76	0,99867	27	0,00	0,00	-1 818,68	89 523,72
2011.02.08 00:00:00	28	AUDUSD	buy	in	1.04	1,01365	28	0,00	0,00	0,00	89 523,72
2011.02.11 12:02:14	29	AUDUSD	sell	out	1.04	0,99636	29	0,00	0,00	-1 798,16	87 725,56
2011.04.06 00:00:00	30	AUDUSD	buy	in	3.18	1,03236	30	0,00	0,00	0,00	87 725,56
2011.05.16 00:00:00	31	AUDUSD	sell	out	3.18	1,05671	31	0,00	0,00	7 743,30	95 468,86
2011.12.07 00:00:00	32	AUDUSD	sell	in	2.13	1,02375	32	0,00	0,00	0,00	95 468,86
2011.12.08 00:00:00	33	AUDUSD	buy	out	2.13	1,02915	33	0,00	0,00	-1 150,20	94 318,66
2011.12.28 00:00:00	34	AUDUSD	sell	in	2.51	1,01430	34	0,00	0,00	0,00	94 318,66
2011.12.30 16:51:35	35	AUDUSD	buy	out	2.51	1,02184	35	0,00	0,00	-1 892,54	92 426,12
2013.01.17 00:00:00	36	AUDUSD	buy	in	2.54	1,05655	36	0,00	0,00	0,00	92 426,12
2013.01.18 11:25:24	37	AUDUSD	sell	out	2.54	1,04926	37	0,00	0,00	-1 851,66	90 574,46
2013.05.13 00:00:00	38	AUDUSD	sell	in	0.61	1,00073	38	0,00	0,00	0,00	90 574,46
2013.07.23 00:00:00	39	AUDUSD	buy	out	0.61	0,92453	39	0,00	0,00	4 648,20	95 222,66
2014.01.27 00:00:00	40	AUDUSD	sell	in	1.45	0,86932	40	0,00	0,00	0,00	95 222,66
2014.01.29 02:06:38	41	AUDUSD	buy	out	1.45	0,88246	41	0,00	0,00	-1 905,30	93 317,36
2014.06.26 00:00:00	42	AUDUSD	buy	in	14.36	0,94031	42	0,00	0,00	0,00	93 317,36
2014.06.30 14:19:16	43	AUDUSD	sell	out	14.36	0,93901	43	0,00	0,00	-1 866,80	91 450,56
2015.02.02 00:00:30	44	AUDUSD	sell	in	1.03	0,77545	44	0,00	0,00	0,00	91 450,56
2015.02.26 00:00:00	45	AUDUSD	buy	out	1.03	0,78853	45	0,00	0,00	-1 347,24	90 103,32
2015.03.17 00:00:00	46	AUDUSD	sell	in	2.73	0,76405	46	0,00	0,00	0,00	90 103,32
2015.03.18 20:00:42	47	AUDUSD	buy	out	2.73	0,77077	47	0,00	0,00	-1 834,56	88 268,76
2015.04.14 00:00:00	48	AUDUSD	sell	in	1.45	0,75883	48	0,00	0,00	0,00	88 268,76
2015.04.16 03:16:30	49	AUDUSD	buy	out	1.45	0,77105	49	0,00	0,00	-1 771,90	86 496,86
2015.07.21 00:00:00	50	AUDUSD	sell	in	1.57	0,73680	50	0,00	0,00	0,00	86 496,86
2015.08.14 00:00:30	51	AUDUSD	buy	out	1.57	0,73639	51	0,00	0,00	64,37	86 561,23
2015.08.31 00:01:00	52	AUDUSD	sell	in	1.08	0,71504	52	0,00	0,00	0,00	86 561,23
2015.09.21 00:01:30	53	AUDUSD	buy	out	1.08	0,71896	53	0,00	0,00	- 423,36	86 137,87
2016.04.12 00:00:00	54	AUDUSD	buy	in	1.96	0,75974	54	0,00	0,00	0,00	86 137,87
2016.05.03 17:06:41	55	AUDUSD	sell	out	1.96	0,75095	55	0,00	0,00	-1 722,84	84 415,03
2016.08.17 00:00:00	56	AUDUSD	buy	in	4.64	0,76976	56	0,00	0,00	0,00	84 415,03
2016.08.17 08:20:40	57	AUDUSD	sell	out	4.64	0,76612	57	0,00	0,00	-1 688,96	82 726,07
2017.07.26 00:14:30	58	AUDUSD	buy	in	5.2	0,79405	58	0,00	0,00	0,00	82 726,07
2017.07.26 04:29:59	59	AUDUSD	sell	out	5.2	0,79086	59	0,00	0,00	-1 658,80	81 067,27
2018.05.03 00:00:00	60	AUDUSD	sell	in	1.67	0,74916	60	0,00	0,00	0,00	81 067,27
2018.05.22 03:37:59	61	AUDUSD	buy	out	1.67	0,75888	61	0,00	0,00	-1 623,24	79 444,03
2018.06.25 00:02:30	62	AUDUSD	sell	in	9.99	0,74384	62	0,00	0,00	0,00	79 444,03
2018.07.09 04:34:36	63	AUDUSD	buy	out	9.99	0,74544	63	0,00	0,00	-1 598,40	77 845,63
2018.08.15 00:00:00	64	AUDUSD	sell	in	0.78	0,72390	64	0,00	0,00	0,00	77 845,63
2018.09.25 00:00:30	65	AUDUSD	buy	out	0.78	0,72540	65	0,00	0,00	- 117,00	77 728,63
2019.01.04 00:02:30	66	AUDUSD	sell	in	2.05	0,70017	66	0,00	0,00	0,00	77 728,63
2019.01.04 17:25:42	67	AUDUSD	buy	out	2.05	0,70776	67	0,00	0,00	-1 555,95	76 172,68
2019.03.13 00:01:30	68	AUDUSD	sell	in	12.8	0,70801	68	0,00	0,00	0,00	76 172,68
2019.03.13 21:58:05	69	AUDUSD	buy	out	12.8	0,70920	69	0,00	0,00	-1 523,20	74 649,48
2019.08.12 00:00:00	70	AUDUSD	sell	in	6.27	0,67803	70	0,00	0,00	0,00	74 649,48
2019.08.13 00:00:01	71	AUDUSD	buy	out	6.27	0,68033	71	0,00	0,00	-1 442,10	73 207,38
2020.03.02 00:00:00	72	AUDUSD	sell	in	0.95	0,64643	72	0,00	0,00	0,00	73 207,38
2020.03.03 17:00:05	73	AUDUSD	buy	out	0.95	0,66199	73	0,00	0,00	-1 478,20	71 729,18
2020.08.19 00:00:00	74	AUDUSD	buy	in	1.07	0,72424	74	0,00	0,00	0,00	71 729,18
2020.09.21 00:00:30	75	AUDUSD	sell	out	1.07	0,72858	75	0,00	0,00	464,38	72 193,56
2020.12.10 00:00:00	76	AUDUSD	buy	in	3	0,74454	76	0,00	0,00	0,00	72 193,56
2020.12.30 23:59:59	77	AUDUSD	sell	out	3	0,76843	77	0,00	0,00	7 167,00	79 360,56

Table 4.3.4– AUD/USD Transactions Report

#### 4.4. BACK-TESTING NZD/USD

For the strategy test on the NZD/USD pair, the trading system processed 4.143 daily bars, containing the open, the low, the high, and the close prices of each trading day, and a total of 173.714.967 ticks. During this period, the alpha model emitted 62 entry signals, of which 36 signals were to open buy positions and 26 signals were to open sell positions. From the total of signals that the model triggered, the risk model rejected 22 of them or 35,53% over the total, and the broker rejected two trades due to the stop-loss size being higher than the limit authorized. On January 18th, 2013, an order was filled with 50,72 contracts, and on September 7th, 2020, an order was filled with 273,6 contracts. Notwithstanding, the automated trade system was able to fill and execute 38 trades. Table 4.4.1 (NZD/USD Signals Triggered by the Alpha Model) details the dates each signal was triggered. It also shows the trades the Risk model accepted or rejected and the reasons for it.

i	date	signal	status	Commentary	i	date	signal	status	Commentary
1	04/01/2005	buy	rejected	SL rejected	32	18/02/2013	buy	approved	
2	28/02/2005	buy	rejected	SL rejected	33	17/04/2013	buy	rejected	SL rejected
3	05/01/2006	sell	rejected	SL rejected	34	13/05/2013	buy	rejected	SL rejected
4	01/02/2006	sell	approved		35	03/07/2013	sell	approved	
5	27/06/2006	sell	approved		36	12/03/2014	buy	approved	
6	05/12/2006	buy	approved		37	15/05/2014	buy	approved	
7	02/02/2007	buy	rejected	SL rejected	38	03/07/2014	buy	approved	
8	28/03/2007	buy	approved		39	14/10/2014	sell	rejected	SL rejected
9	12/06/2007	buy	approved		40	11/12/2014	sell	approved	
10	17/12/2007	buy	rejected	SL rejected	41	28/01/2015	sell	approved	
11	17/01/2008	buy	rejected	SL rejected	42	17/03/2015	sell	rejected	SL rejected
12	11/02/2008	buy	rejected	SL rejected	43	11/06/2015	sell	rejected	SL rejected
13	06/08/2008	sell	approved		44	18/08/2015	sell	approved	
14	14/10/2008	sell	approved		45	04/04/2016	buy	approved	
15	05/02/2009	sell	approved		46	23/06/2016	buy	approved	
16	02/03/2009	sell	approved		47	12/08/2016	buy	approved	
17	28/07/2009	buy	approved		48	19/04/2017	sell	rejected	SL rejected
18	25/11/2009	buy	rejected	SL rejected	49	05/05/2017	sell	approved	
19	02/06/2010	sell	rejected	SL rejected	50	08/08/2017	buy	rejected	SL rejected
20	14/06/2010	sell	rejected	SL rejected	51	24/04/2018	buy	rejected	SL rejected
21	13/10/2010	buy	approved		52	18/07/2018	sell	approved	
22	09/11/2010	buy	approved		53	15/08/2018	sell	approved	
23	24/01/2010	buy	rejected	SL rejected	54	14/09/2018	sell	approved	
24	02/02/2011	buy	approved		55	12/10/2018	sell	rejected	SL rejected
25	04/05/2011	buy	rejected	SL rejected	56	06/03/2018	buy	rejected	SL rejected
26	03/06/2011	buy	approved		57	27/03/2019	buy	approved	
27	08/07/2011	buy	approved		58	19/08/2019	sell	approved	
28	28/12/2011	sell	approved		59	30/09/2019	sell	approved	
29	06/11/2012	buy	approved		60	18/03/2020	sell	approved	
30	14/12/2012	buy	approved		61	07/09/2020	buy	approved	Invalid Volume
31	18/01/2013	buy	approved	Invalid Volume	62	13/11/2020	buy	approved	

Table 4.4.1– NZD/USD Signals Triggered by the Alpha Model

The main reason for these rejections, as seen in table 4.4.1, was that the prices that the strategy set for the SL limit order for the trades were above entry price, in case of longs positions, and below the entry price, in case of short positions. Table 4.4.2 (NZD/USD Stop-loss Placement of the Rejected Trades) details the rejected trades events with each entry price, the stop-loss limit order prices, and the distance between them. The distance between the stop-loss price and entry price was 191,8 pips, varying from 3 pips and negative 194,8 pips, with a mean at 63,7 pips. See Graph 4.4.1 (Distribution of NZD/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades).

i	Type	EP	SL	Diff.
1	Buy	0,7144	0,7193	-0,0049
2	Buy	0,7216	0,7219	-0,0003
3	Sell	0,6865	0,6835	-0,003
4	Buy	0,6828	0,6921	-0,0093
5	Buy	0,7689	0,7718	-0,0029
6	Buy	0,7698	0,7725	-0,0027
7	Buy	0,7879	0,7898	-0,0019
8	Buy	0,72623	0,74299	-0,01676
9	Sell	0,6754	0,67415	-0,00125
10	Sell	0,69024	0,67102	-0,01922
11	Buy	0,75864	0,76709	-0,00845
12	Buy	0,79866	0,80023	-0,00157
13	Buy	0,84926	0,85141	-0,00215
14	Buy	0,82902	0,8485	-0,01948
15	Sell	0,78883	0,78728	-0,00155
16	Sell	0,73681	0,73579	-0,00102
17	Sell	0,71972	0,71677	-0,00295
18	Sell	0,70406	0,69739	-0,00667
19	Buy	0,7363	0,74607	-0,00977
20	Buy	0,71516	0,73262	-0,01746
21	Sell	0,65179	0,64844	-0,00335
22	Buy	0,68	0,68347	-0,00347

Table 4.4.2– NZD/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades

From Table 4.4.3 (NZD/USD Position Risk-Reward ratio (in pips)) below, one can observe that the strategy's highest risk-reward earned by the strategy was 4,08 earned per point risked and the lowest was of negative -1.03. The average risk-reward ratio of this back-test sample was negative 0,36 pips. It means that the automated trading system managed to lose, on average, 0,36 cents for every 1\$ risked in a single trade.



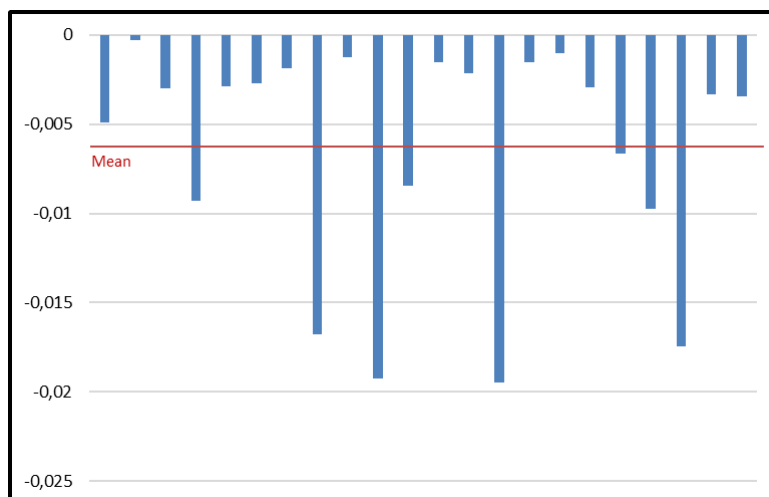


Figure 4.4.1 – NZD/USD Distance between Stop-loss Prices and Entry Prices of Rejected Trades

Type	P&L	SL Size	RR	Type	P&L	SL Size	RR
sell	-9	9	- 1,00	sell	-99,2	98,6	-1,00
sell	-146	179	- 0,82	buy	160,3	83	-1,00
buy	18,8	220,1	0,09	buy	-41,5	41,5	-0,73
buy	183	141	1,30	buy	-48,9	48,9	-1,02
buy	-47	47	- 1,00	sell	-7,8	7,6	-1,00
sell	401,5	138	2,91	sell	-98,2	262,9	0,04
sell	357	283	1,26	sell	-66,3	66,1	-0,24
sell	-176,1	175	- 1,01	buy	-9,2	223,5	-1,00
sell	-212,3	212,1	- 1,00	buy	-194,4	194,4	-1,00
buy	-78,4	77,9	- 1,01	buy	97,8	94,1	-1,00
buy	-94,1	94,1	- 1,00	sell	-19,7	19,7	-1,00
buy	-239,7	239,3	- 1,00	sell	-53,4	53,4	-1,01
buy	-168	167,5	- 1,00	sell	-146,2	193,8	-0,08
buy	-94,9	94,8	- 1,00	sell	-29	29	-1,00
buy	-88,6	88,6	- 1,00	buy	-82,5	82,1	-1,00
sell	-52,3	52,2	- 1,00	sell	44,7	48,5	-1,00
buy	-80,3	80,2	- 1,00	sell	-17,9	17,8	-1,01
buy	-122,2	122,2	- 1,00	sell	-19,6	380,9	0,32
buy	-128,8	128,7	- 1,00	buy	361,9	88,6	4,96

Table 4.4.3 – NZD/USD Position Reward-risk ratio (in pips)

The strategy delivered a total of 1.625 pips in profits and 2.671,5 pips in losses over the period tested, resulting in a net return of negative 1.046,5 pips. The trade that returned the highest loss was 239,7 pips, while the trade with the highest return was 401,5 pips. The average of pips lost per trade was 27,54 and a standard deviation of 146,78 pips. Moreover, the back-test for NZD/USD showed that from the 38 orders the execution model filled and executed, the stop-loss sizes vary from 7,6 pips to 380,9 pips. The stop-loss size samples presented a mean of 120,634 pips, a standard deviation of 85,38 pips, and a range of 373,3 pips. See Figure 4.4.2 (NZD/USD Position Information (in pips)).

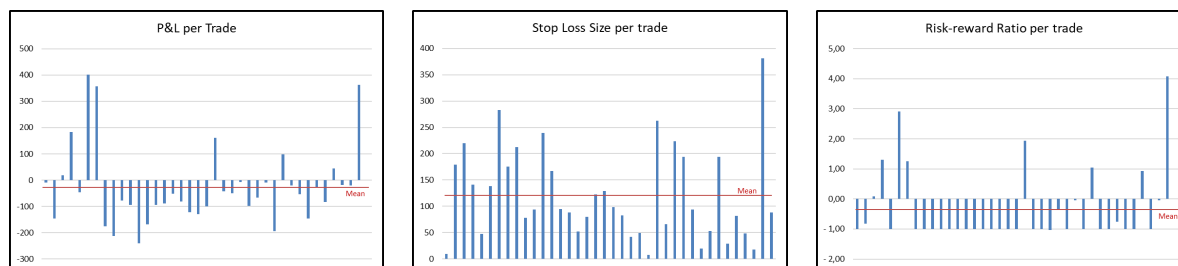


Figure 4.4.2– NZD/USD Position Information (in pips)

The strategy generated 21.103,14\$ in gains and 47.375,96\$ in losses, resulting in a net loss of 26.272,82\$ or a negative 26,27 return over the initial trading capital. The absolute balance drawdown of the account was 31.600,83\$, or negative 31,6%, while the absolute equity drawdown was 32.290,84 \$ or 32,3%. Moreover, the simulation reached a maximal balance drawdown of 36.467,81\$ or 34,8%, and a maximal equity drawdown of 41.445,4\$ or 38%. One can visualize the information in Graph 4.4.3 (NZD/USD Balance and Equity Evolution) below.

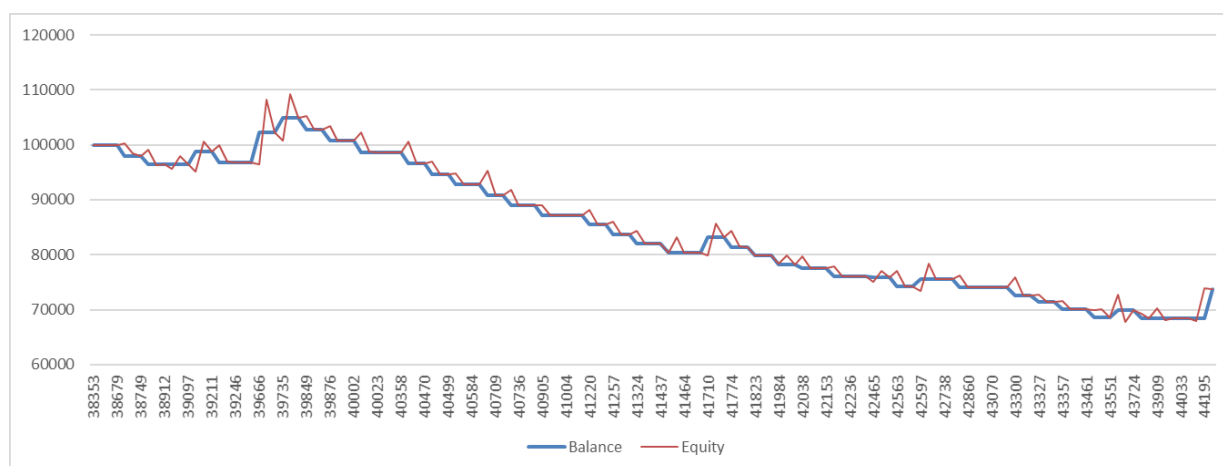


Figure 4.4.3– NZD/USD Balance and Equity Evolution

Table 4.4.4 (NZD/USD Transactions Report) below details each transaction the trading system accomplished during the test. Of the 38 trades that the algorithm executed, 20 trades were longs, and 18 were shorts. Nevertheless, eight trades resulted in profits, and the remaining 30 trades resulted in losses. From these losses, the stop-loss limit order that the risk module set closed 26 trades, and the position management module closed prematurely four trades due to the trend condition no longer being valid. This result shows that the strategy had a win ratio over the back-testing period of 20%.

The most significant profit-taking in trade was 5.575,64\$, with an average profit of 2.637,89\$. The most considerable loss in trade was 2.113,92\$ with an average loss of 1.579,2\$. The position's maximal holding time was 1.104 hours, while the trade with the minimal holding duration of 360 hours. The average duration of the trades was 270 hours and 38 minutes. Finally, the number of consecutive trades with profit in the test was 2, totalizing 8.118,43\$, and the number of consecutive losses was 13, totalizing -24.546,86\$. See **Appendix D** of the supplementary electronic repository of this work for the complete output of the back-testing.

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2005.01.01 00:00:00	1		balance					0,00	0,00	100 000,00	100 000,00
2006.02.01 00:00:00	2	NZDUSD	sell	in	22.22	0,68770	2	0,00	0,00	0,00	100 000,00
2006.02.01 00:52:59	3	NZDUSD	buy	out	22.22	0,68860	3	0,00	0,00	-1 999,80	98 000,20
2006.06.27 00:00:30	4	NZDUSD	sell	in	1.09	0,60400	4	0,00	0,00	0,00	98 000,20
2006.07.14 00:00:30	5	NZDUSD	buy	out	1.09	0,61860	5	0,00	- 12,38	-1 591,40	96 396,42
2006.12.05 00:00:00	6	NZDUSD	buy	in	0.88	0,69051	6	0,00	0,00	0,00	96 396,42
2007.01.15 00:00:00	7	NZDUSD	sell	out	0.88	0,69239	7	0,00	- 127,84	165,44	96 434,02
2007.03.28 00:00:00	8	NZDUSD	buy	in	1.37	0,71750	8	0,00	0,00	0,00	96 434,02
2007.05.09 00:00:00	9	NZDUSD	sell	out	1.37	0,73580	9	0,00	- 203,70	2 507,10	98 737,42
2007.06.12 00:00:00	10	NZDUSD	buy	in	4.2	0,75100	10	0,00	0,00	0,00	98 737,42
2007.06.13 12:03:51	11	NZDUSD	sell	out	4.2	0,74630	11	0,00	- 14,87	-1 974,00	96 748,55
2008.08.06 00:00:00	12	NZDUSD	sell	in	1.4	0,72570	12	0,00	0,00	0,00	96 748,55
2008.09.29 00:00:00	13	NZDUSD	buy	out	1.4	0,68555	13	0,00	- 45,36	5 621,00	102 324,19
2008.10.14 00:00:00	14	NZDUSD	sell	in	0.72	0,61410	14	0,00	0,00	0,00	102 324,19
2008.12.17 00:00:00	15	NZDUSD	buy	out	0.72	0,57840	15	0,00	- 27,61	2 570,40	104 866,98
2009.02.05 00:00:00	16	NZDUSD	sell	in	1.2	0,50770	16	0,00	0,00	0,00	104 866,98
2009.02.06 15:03:27	17	NZDUSD	buy	out	1.2	0,52531	17	0,00	- 0,72	-2 113,20	102 753,06
2009.03.02 00:00:30	18	NZDUSD	sell	in	0.97	0,49675	18	0,00	0,00	0,00	102 753,06
2009.03.12 19:00:00	19	NZDUSD	buy	out	0.97	0,51798	19	0,00	- 6,98	-2 059,31	100 686,77
2009.07.28 00:00:30	20	NZDUSD	buy	in	2.59	0,65740	20	0,00	0,00	0,00	100 686,77
2009.07.29 23:13:05	21	NZDUSD	sell	out	2.59	0,64956	21	0,00	- 9,17	-2 030,56	98 647,04
2010.10.13 00:00:30	22	NZDUSD	buy	in	2.1	0,75515	22	0,00	0,00	0,00	98 647,04
2010.10.19 15:11:16	23	NZDUSD	sell	out	2.1	0,74574	23	0,00	- 44,59	-1 976,10	96 626,35
2010.11.09 00:00:00	24	NZDUSD	buy	in	0.81	0,78728	24	0,00	0,00	0,00	96 626,35
2010.11.17 09:00:36	25	NZDUSD	sell	out	0.81	0,76331	25	0,00	- 22,95	-1 941,57	94 661,83
2011.02.02 00:00:00	26	NZDUSD	buy	in	1.13	0,78098	26	0,00	0,00	0,00	94 661,83
2011.02.10 16:09:59	27	NZDUSD	sell	out	1.13	0,76418	27	0,00	- 40,00	-1 898,40	92 723,43
2011.06.03 00:00:00	28	NZDUSD	buy	in	1.96	0,81641	28	0,00	0,00	0,00	92 723,43
2011.06.15 18:19:12	29	NZDUSD	sell	out	1.96	0,80692	29	0,00	- 69,40	-1 860,04	90 793,99
2011.07.08 00:00:00	30	NZDUSD	buy	in	2.05	0,83288	30	0,00	0,00	0,00	90 793,99
2011.07.12 02:21:39	31	NZDUSD	sell	out	2.05	0,82402	31	0,00	- 14,52	-1 816,30	88 963,17
2011.12.28 00:00:00	32	NZDUSD	sell	in	3.41	0,77214	32	0,00	0,00	0,00	88 963,17
2011.12.28 12:39:17	33	NZDUSD	buy	out	3.41	0,77737	33	0,00	0,00	-1 783,43	87 179,74
2012.11.06 00:00:00	34	NZDUSD	buy	in	2.17	0,82630	34	0,00	0,00	0,00	87 179,74
2012.11.07 22:56:26	35	NZDUSD	sell	out	2.17	0,81827	35	0,00	- 7,68	-1 742,51	85 429,55
2012.12.14 00:00:00	36	NZDUSD	buy	in	1.4	0,84308	36	0,00	0,00	0,00	85 429,55
2012.12.21 02:10:25	37	NZDUSD	sell	out	1.4	0,83086	37	0,00	- 34,71	-1 710,80	83 684,04
2013.02.18 00:00:00	38	NZDUSD	buy	in	1.3	0,84372	38	0,00	0,00	0,00	83 684,04
2013.02.26 08:30:43	39	NZDUSD	sell	out	1.3	0,83084	39	0,00	- 36,81	-1 674,40	81 972,83
2013.07.03 00:00:00	40	NZDUSD	sell	in	1.66	0,77619	40	0,00	0,00	0,00	81 972,83
2013.07.09 09:00:26	41	NZDUSD	buy	out	1.66	0,78611	41	0,00	- 5,99	-1 646,72	80 320,12
2014.03.12 00:00:00	42	NZDUSD	buy	in	1.94	0,84590	42	0,00	0,00	0,00	80 320,12
2014.04.24 00:00:00	43	NZDUSD	sell	out	1.94	0,86193	43	0,00	- 309,08	3 109,82	83 120,86
2014.05.15 00:00:00	44	NZDUSD	buy	in	4.01	0,86662	44	0,00	0,00	0,00	83 120,86
2014.05.16 09:25:33	45	NZDUSD	sell	out	4.01	0,86247	45	0,00	- 14,20	-1 664,15	81 442,51
2014.07.03 00:00:00	46	NZDUSD	buy	in	3.33	0,87759	46	0,00	0,00	0,00	81 442,51
2014.07.03 14:35:38	47	NZDUSD	sell	out	3.33	0,87270	47	0,00	0,00	-1 628,37	79 814,14
2014.12.11 00:00:00	48	NZDUSD	sell	in	21	0,78131	48	0,00	0,00	0,00	79 814,14
2014.12.11 00:16:42	49	NZDUSD	buy	out	21	0,78209	49	0,00	0,00	-1 638,00	78 176,14
2015.01.28 00:00:00	50	NZDUSD	sell	in	0.59	0,74441	50	0,00	0,00	0,00	78 176,14
2015.02.18 00:00:00	51	NZDUSD	buy	out	0.59	0,75423	51	0,00	- 7,38	- 579,38	77 589,38
2015.08.18 00:00:30	52	NZDUSD	sell	in	2.35	0,65658	52	0,00	0,00	0,00	77 589,38
2015.08.20 17:30:17	53	NZDUSD	buy	out	2.35	0,66321	53	0,00	- 5,64	-1 558,05	76 025,69
2016.04.04 00:03:00	54	NZDUSD	buy	in	0.68	0,68903	54	0,00	0,00	0,00	76 025,69
2016.05.06 00:00:30	55	NZDUSD	sell	out	0.68	0,68811	55	0,00	- 81,89	- 62,56	75 881,24
2016.06.23 00:00:00	56	NZDUSD	buy	in	0.78	0,71619	56	0,00	0,00	0,00	75 881,24
2016.07.21 00:29:36	57	NZDUSD	sell	out	0.78	0,69675	57	0,00	- 77,28	-1 516,32	74 287,64
2016.08.12 00:00:00	58	NZDUSD	buy	in	1.58	0,72147	58	0,00	0,00	0,00	74 287,64
2016.09.23 00:00:00	59	NZDUSD	sell	out	1.58	0,73125	59	0,00	- 234,84	1 545,24	75 598,04

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2017.05.05 00:00:00	60	NZDUSD	sell	in	7.67	0,68699	60	0,00	0,00	0,00	75 598,04
2017.05.05 10:54:27	61	NZDUSD	buy	out	7.67	0,68896	61	0,00	0,00	-1 510,99	74 087,05
2018.07.18 00:00:00	62	NZDUSD	sell	in	2.77	0,67807	62	0,00	0,00	0,00	74 087,05
2018.07.25 22:37:22	63	NZDUSD	buy	out	2.77	0,68341	63	0,00	- 11,63	-1 479,18	72 596,24
2018.08.15 00:00:30	64	NZDUSD	sell	in	0.75	0,65674	64	0,00	0,00	0,00	72 596,24
2018.08.30 00:01:00	65	NZDUSD	buy	out	0.75	0,67136	65	0,00	- 7,65	-1 096,50	71 492,09
2018.09.14 00:00:00	66	NZDUSD	sell	in	4.93	0,65631	66	0,00	0,00	0,00	71 492,09
2018.09.14 09:46:05	67	NZDUSD	buy	out	4.93	0,65921	67	0,00	0,00	-1 429,70	70 062,39
2019.03.27 00:01:30	68	NZDUSD	buy	in	1.71	0,69098	68	0,00	0,00	0,00	70 062,39
2019.03.27 04:00:41	69	NZDUSD	sell	out	1.71	0,68273	69	0,00	0,00	-1 410,75	68 651,64
2019.08.19 00:00:00	70	NZDUSD	sell	in	2.8	0,64257	70	0,00	0,00	0,00	68 651,64
2019.09.16 00:00:00	71	NZDUSD	buy	out	2.8	0,63810	71	0,00	- 47,04	1 251,60	69 856,20
2019.09.30 00:00:00	72	NZDUSD	sell	in	7.72	0,62806	72	0,00	0,00	0,00	69 856,20
2019.09.30 00:00:00	73	NZDUSD	buy	out	7.72	0,62985	73	0,00	0,00	-1 381,88	68 474,32
2020.03.18 00:00:00	74	NZDUSD	sell	in	0.36	0,59609	74	0,00	0,00	0,00	68 474,32
2020.04.08 00:00:00	75	NZDUSD	buy	out	0.36	0,59805	75	0,00	- 4,59	- 70,56	68 399,17
2020.11.13 00:00:00	76	NZDUSD	buy	in	1.54	0,68393	76	0,00	0,00	0,00	68 399,17
2020.12.30 23:59:59	77	NZDUSD	sell	out	1.54	0,72012	77	0,00	- 245,25	5 573,26	73 727,18

Table 4.4.4 – NZD/USD Transactions Report

## 4.5. BACK-TESTING USD/CHF

When back-testing the USD/CHF, the trading system processed 4.143 daily bars, containing the open, the low, the high, and the close prices of each trading day, and a total of 191.421.581 ticks. During this period, the alpha model emitted 50 entry signals, of which 16 signals were to open buy positions and 34 signals were to open sell positions. From the total of signals that the model triggered, the risk model rejected 20 of them or 40% over the total, Excluded the rejections, the automated trade system was able to fill and execute 30 trades Table 4.6.1 (USD/CHF Signals Triggered by the Alpha Model) shows the dates each signal was triggered. It also shows if the risk model accepted or rejected the signals and the reasons for it.

i	date	signal	status	Commentary	i	date	signal	status	Commentary
1	04/01/2005	sell	rejected	SL rejected	26	27/12/2012	sell	approved	
2	15/06/2005	buy	approved		27	19/02/2013	sell	rejected	SL rejected
3	15/11/2005	buy	approved		28	30/05/2013	buy	rejected	SL rejected
4	22/05/2006	sell	rejected	SL rejected	29	11/10/2013	sell	rejected	SL rejected
5	25/04/2007	sell	approved		30	30/10/2013	sell	rejected	SL rejected
6	15/08/2007	sell	rejected	SL rejected	31	18/12/2013	sell	approved	
7	18/09/2007	sell	approved		32	26/02/2014	sell	approved	
8	01/11/2007	sell	approved		33	02/09/2014	buy	approved	
9	24/01/2008	sell	approved		34	07/11/2014	buy	approved	
10	04/03/2008	sell	approved		35	10/12/2014	buy	rejected	SL rejected
11	14/10/2008	buy	approved		36	10/11/2015	buy	approved	
12	12/06/2009	sell	approved		37	02/02/2016	buy	approved	
13	23/07/2009	sell	approved		38	29/06/2016	sell	rejected	SL rejected
14	21/10/2009	sell	approved		39	24/11/2016	buy	approved	
15	06/05/2010	buy	approved		40	13/06/2017	sell	rejected	SL rejected

i	date	signal	status	Commentary	i	date	signal	status	Commentary
16	11/10/2010	sell	approved		41	07/07/2017	sell	rejected	SL rejected
17	30/12/2010	sell	approved		42	14/09/2017	sell	rejected	SL rejected
18	03/02/2011	sell	approved		43	20/03/2017	buy	rejected	SL rejected
19	03/03/2011	sell	approved		44	10/05/2019	buy	rejected	SL rejected
20	21/04/2011	sell	approved		45	15/08/2019	sell	approved	
21	06/06/2011	sell	approved		46	08/01/2020	sell	rejected	SL rejected
22	06/07/2011	sell	rejected	SL rejected	47	16/03/2020	sell	rejected	SL rejected
23	21/12/2011	buy	rejected	SL rejected	48	18/06/2020	sell	rejected	SL rejected
24	04/06/2012	buy	approved		49	03/11/2020	sell	rejected	SL rejected
25	10/07/2012	buy	approved		50	02/12/2020	sell	approved	

Table 4.5.1 – USD/CHF Signals Triggered by the Alpha Model

The main reason for these rejections, as seen in table Figure 4.5.1 (USD/CHF Distances between Stop-loss Prices and Entry Prices of Rejected Trades), was that the prices that the strategy set for the SL limit order for the trades were above entry price, in case of longs positions, and below the entry price, in case of short positions. Table 4.5.2 (USD/CHF Stop-loss Placement of the Rejected Trades) details the rejected trades events with each entry price, the stop-loss limit order prices, and the distance between them. The distance between the stop-loss price and entry price was 181,1 pips, varying from negative 3,3 pips and negative 184,4 pips, with a mean at negative 51,8 pips.

i	Type	EP	SL	Diff.
1	Sell	1,1484	1,1381	-0,0103
2	Sell	1,2174	1,2137	-0,0037
3	Sell	1,2105	1,1992	-0,0113
4	Sell	0,84083	0,83673	-0,0041
5	Buy	0,93183	0,94289	-0,01106
6	Sell	0,92309	0,92141	-0,00168
7	Buy	0,96196	0,96338	-0,00142
8	Sell	0,91112	0,90816	-0,00296
9	Sell	0,89872	0,89655	-0,00217
10	Buy	0,96999	0,97144	-0,00145
11	Sell	0,98119	0,96275	-0,01844
12	Sell	0,96826	0,96528	-0,00298
13	Sell	0,96031	0,95978	-0,00053
14	Sell	0,96376	0,95935	-0,00441
15	Buy	0,99965	1,00265	-0,003
16	Buy	1,0148	1,01601	-0,00121
17	Sell	0,97003	0,9697	-0,00033
18	Sell	0,94493	0,9336	-0,01133
19	Sell	0,94855	0,94597	-0,00258
20	Sell	0,91841	0,9097	-0,00871

Table 4.5.2 – USD/CHF Distance between Stop-loss Prices and Entry Prices of Rejected Trades

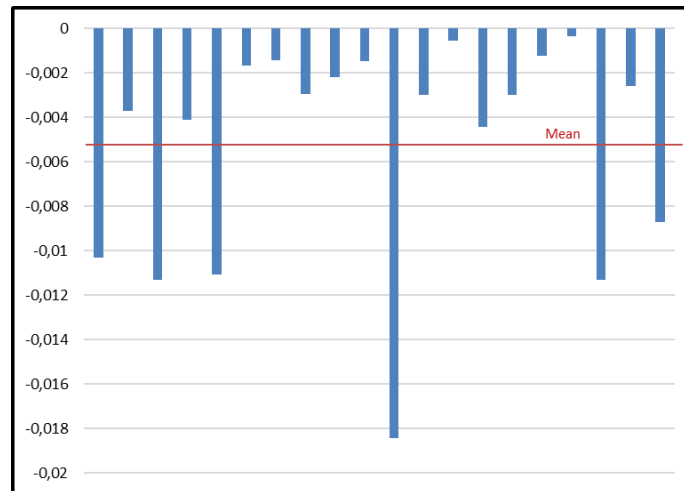


Figure 4.5.1– USD/CHF Distance between Stop-loss Prices and Entry Prices of Rejected Trades

From Table 4.5.3 (USD/CHF Position Risk-Reward ratio (in pips)) below, one can observe that the highest risk-reward earned by the strategy was 3,97 per point risked, and the lowest was negative 1,03. The automated trading system managed to lose, on average, 0.28 monetary units for every one monetary unit risked in a single trade.

Type	P&L	SL Size	risk-reward	Type	P&L	SL Size	risk-reward
buy	198,00	372	0,53	sell	77,50	87	- 1,01
buy	- 118,70	116	- 1,02	sell	- 182,00	182	- 1,02
sell	- 78,60	78	- 1,01	buy	- 130,20	130	- 0,02
sell	53,00	29	1,83	buy	-66	241,5	-1,00
sell	289,00	147	1,97	sell	-22,1	22	6,69
sell	- 175,00	175	- 1,00	sell	-38,3	38,3	-1,00
sell	405,00	500	0,81	sell	-26,4	26,4	-1,00
buy	- 21,70	21	- 1,03	buy	235,2	59,2	-1,02
sell	- 194,00	194	- 1,00	buy	-171,4	171,4	-1,00
sell	- 122,40	122	- 1,00	buy	-196,8	196,8	-0,59
sell	- 105,00	105	- 1,00	buy	-76,5	76,5	-1,00
buy	249,20	371	0,67	buy	11,7	164,7	0,02
sell	- 186,00	186	- 1,00	sell	-60,2	60,2	-0,66
sell	- 222,90	223	- 1,00	sell	176,4	146,4	-0,71
sell	- 77,60	77	- 1,00				
sell	- 95,50	95	- 1,00				

Table 4.5.3 – USD/CHF Position Risk-Reward ratio (in pips)

The strategy delivered a total of 1.695 pips in profits and 2.367,3 pips in losses over the period tested, resulting in a net return of negative 672,3 pips. The trade that returned the highest loss was 222,9 pips, while the one with the highest profit was 405. The average of pips lost per trade was - 22,41 pips and a standard deviation of 161,07 pips. Moreover, the back-test for USD/CHF showed

that from the 30 orders the execution model filled and executed, the stop-loss sizes vary from 21 pips to 500 pips. The stop-loss size samples presented a mean of 147,11 pips, a standard deviation of 109,65 pips, and a range of 479 pips. See Graph 4.5.2 – NZD/CHF Position Information (in pips).

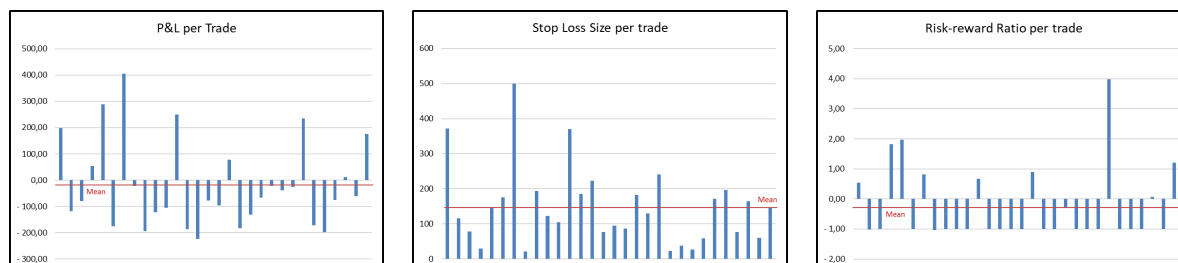
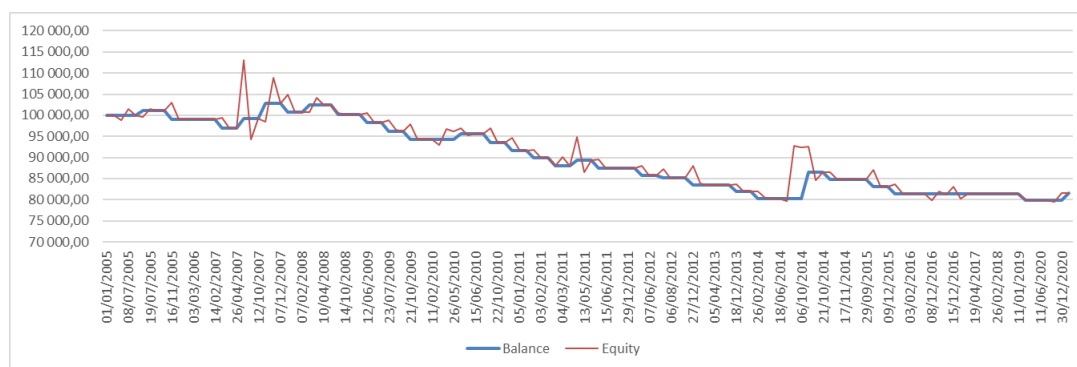


Figure 4.5.2 – USD/CHF Position Information (in pips)

The strategy generated 19.191,8\$ in gains and 37.644,34\$ in losses, resulting in a net loss of 19.191,8\$ or a negative 18,5% return over the initial trading capital. The absolute balance drawdown of the account was 20.197,41\$, or negative 20,2%, while the absolute equity drawdown was 20.443,11\$ or 20,44%. Moreover, the simulation reached the maximal balance drawdown of 23.106,08\$ or 23,11% and a maximal equity drawdown of 33.426,5\$ or 33,43%. See 4.5.3 (USD/CHF Balance and Equity Evolution).



Graph 4.5.1 – USD/CHF Balance and Equity Evolution

Table 4.5.4 (USD/CHF Transactions Report) details each trading system's transaction accomplished during the test. Of the 30 trades that the algorithm executed, 11 trades were longs, and 19 trades were shorts. Nevertheless, nine trades resulted in profits, and the remaining 21 trades resulted in losses. From these losses, the stop-loss limit order that the risk module set closed 18 trades, and the position management module closed prematurely three trades due to the trend condition no longer being valid. This result shows that the strategy had a win ratio over the back-testing period of 30%.

The largest profit-taken in trade was 6.235,2\$, with an average profit of 2.132,42 \$. The most significant loss in trade was -2.135,56\$ with an average loss of -1.792,59 \$. The position's maximal holding time was 840 hours, while the trade with the minimal holding duration of 43 minutes and 44 seconds. The average duration of the trades was 278:36:28. Finally, the number of consecutive trades with profit in the test was 2, totalizing 5.973,97\$, and the number of consecutive losses was 6, totalizing -9.057,74\$. See **Appendix C** of the supplementary electronic repository of this work for the complete output of the back-testing.

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2005.01.01 00:00:00	1		balance					0,00	0,00	100 000,00	100 000,00
2005.06.15 00:01:00	2	USDCHF	buy	in	0.69	1,27830	2	0,00	0,00	0,00	100 000,00
2005.07.25 00:01:00	3	USDCHF	sell	out	0.69	1,29810	3	0,00	4,36	1 052,46	101 056,82
2005.11.15 00:01:00	4	USDCHF	buy	in	2.3	1,31770	4	0,00	0,00	0,00	101 056,82
2005.11.28 19:40:36	5	USDCHF	sell	out	2.3	1,30583	5	0,00	4,54	-2 090,70	98 970,66
2007.04.25 00:01:00	6	USDCHF	sell	in	3.05	1,20120	6	0,00	0,00	0,00	98 970,66
2007.04.26 13:34:45	7	USDCHF	buy	out	3.05	1,20906	7	0,00	- 53,18	-1 982,78	96 934,70
2007.09.18 00:01:00	8	USDCHF	sell	in	7.94	1,18700	8	0,00	0,00	0,00	96 934,70
2007.10.12 00:00:00	9	USDCHF	buy	out	7.94	1,18170	9	0,00	-1 227,63	3 561,14	99 268,21
2007.11.01 00:03:30	10	USDCHF	sell	in	1.56	1,15860	10	0,00	0,00	0,00	99 268,21
2007.12.07 00:00:00	11	USDCHF	buy	out	1.56	1,12970	11	0,00	- 350,33	3 990,79	102 908,67
2008.01.24 00:00:30	12	USDCHF	sell	in	1.28	1,09110	12	0,00	0,00	0,00	102 908,67
2008.02.07 19:28:59	13	USDCHF	buy	out	1.28	1,10860	13	0,00	- 114,99	-2 020,57	100 773,11
2008.03.04 00:02:00	14	USDCHF	sell	in	0.42	1,04170	14	0,00	0,00	0,00	100 773,11
2008.04.10 00:00:00	15	USDCHF	buy	out	0.42	1,00120	15	0,00	- 113,58	1 698,96	102 358,49
2008.10.14 00:00:00	16	USDCHF	buy	in	11.09	1,13800	16	0,00	0,00	0,00	102 358,49
2008.10.14 00:43:44	17	USDCHF	sell	out	11.09	1,13583	17	0,00	0,00	-2 118,74	100 239,75
2009.06.12 00:00:01	18	USDCHF	sell	in	1.11	1,07110	18	0,00	0,00	0,00	100 239,75
2009.06.15 09:32:39	19	USDCHF	buy	out	1.11	1,09050	19	0,00	- 7,20	-1 974,69	98 257,86
2009.07.23 00:00:00	20	USDCHF	sell	in	1.72	1,06670	20	0,00	0,00	0,00	98 257,86
2009.07.28 17:12:28	21	USDCHF	buy	out	1.72	1,07894	21	0,00	- 33,68	-1 951,25	96 272,93
2009.10.21 00:00:30	22	USDCHF	sell	in	1.86	1,01210	22	0,00	0,00	0,00	96 272,93
2009.10.27 15:02:41	23	USDCHF	buy	out	1.86	1,02260	23	0,00	- 77,43	-1 909,84	94 285,66
2010.05.06 00:00:00	24	USDCHF	buy	in	0.57	1,11773	24	0,00	0,00	0,00	94 285,66
2010.06.15 00:00:00	25	USDCHF	sell	out	0.57	1,14265	25	0,00	3,80	1 243,11	95 532,57
2010.10.11 00:00:00	26	USDCHF	sell	in	0.99	0,96030	26	0,00	0,00	0,00	95 532,57
2010.10.22 17:45:16	27	USDCHF	buy	out	0.99	0,97890	27	0,00	- 93,74	-1 881,09	93 557,74
2010.12.30 00:00:00	28	USDCHF	sell	in	0.79	0,94408	28	0,00	0,00	0,00	93 557,74
2011.01.05 16:14:34	29	USDCHF	buy	out	0.79	0,96637	29	0,00	- 23,58	-1 822,19	91 711,97
2011.02.03 00:01:00	30	USDCHF	sell	in	2.23	0,94033	30	0,00	0,00	0,00	91 711,97
2011.02.03 14:49:28	31	USDCHF	buy	out	2.23	0,94809	31	0,00	0,00	-1 825,23	89 886,74
2011.03.03 00:00:00	32	USDCHF	sell	in	1.74	0,92354	32	0,00	0,00	0,00	89 886,74
2011.03.08 08:45:25	33	USDCHF	buy	out	1.74	0,93309	33	0,00	- 39,38	-1 780,86	88 066,50
2011.04.21 00:00:00	34	USDCHF	sell	in	1.8	0,88821	34	0,00	0,00	0,00	88 066,50
2011.05.18 00:00:30	35	USDCHF	buy	out	1.8	0,88046	35	0,00	- 359,46	1 584,40	89 291,44
2011.06.06 00:00:00	36	USDCHF	sell	in	0.82	0,83483	36	0,00	0,00	0,00	89 291,44
2011.06.15 18:42:15	37	USDCHF	buy	out	0.82	0,85303	37	0,00	- 61,60	-1 749,53	87 480,31
2012.06.04 00:00:00	38	USDCHF	buy	in	1.3	0,96587	38	0,00	0,00	0,00	87 480,31
2012.06.07 14:18:40	39	USDCHF	sell	out	1.3	0,95285	39	0,00	1,36	-1 776,36	85 705,31
2012.07.10 00:00:00	40	USDCHF	buy	in	0.69	0,97538	40	0,00	0,00	0,00	85 705,31
2012.08.07 00:00:00	41	USDCHF	sell	out	0.69	0,96878	41	0,00	3,92	- 470,08	85 239,15
2012.12.27 00:00:00	42	USDCHF	sell	in	7.08	0,91309	42	0,00	0,00	0,00	85 239,15
2012.12.27 18:28:27	43	USDCHF	buy	out	7.08	0,91530	43	0,00	0,00	-1 709,47	83 529,68
2013.12.18 00:00:00	44	USDCHF	sell	in	3.86	0,88479	44	0,00	0,00	0,00	83 529,68
2013.12.18 10:54:26	45	USDCHF	buy	out	3.86	0,88862	45	0,00	0,00	-1 663,68	81 866,00
2014.02.26 00:00:00	46	USDCHF	sell	in	5.5	0,88690	46	0,00	0,00	0,00	81 866,00
2014.02.26 14:30:27	47	USDCHF	buy	out	5.5	0,88954	47	0,00	0,00	-1 632,30	80 233,70
2014.09.02 00:00:00	48	USDCHF	buy	in	2.49	0,91965	48	0,00	0,00	0,00	80 233,70
2014.10.21 00:00:00	49	USDCHF	sell	out	2.49	0,94317	49	0,00	25,84	6 209,36	86 468,90
2014.11.07 00:00:00	50	USDCHF	buy	in	0.98	0,97286	50	0,00	0,00	0,00	86 468,90
2014.11.17 03:32:35	51	USDCHF	sell	out	0.98	0,95572	51	0,00	1,61	-1 757,54	84 712,97
2015.11.10 00:01:30	52	USDCHF	buy	in	0.86	1,00407	52	0,00	0,00	0,00	84 712,97



Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2015.12.09 20:07:37	53	USDCHF	sell	out	0.86	0,98439	53	0,00	4,93	-1 719,32	82 998,58
2016.02.02 00:00:00	54	USDCHF	buy	in	2.21	1,01940	54	0,00	0,00	0,00	82 998,58
2016.02.03 17:00:12	55	USDCHF	sell	out	2.21	1,01175	55	0,00	0,43	-1 671,02	81 327,99
2016.11.24 00:00:00	56	USDCHF	buy	in	1	1,01583	56	0,00	0,00	0,00	81 327,99
2017.01.09 00:00:30	57	USDCHF	sell	out	1	1,01700	57	0,00	8,67	115,04	81 451,70
2019.08.15 00:00:00	58	USDCHF	sell	in	2.65	0,97262	58	0,00	0,00	0,00	81 451,70
2019.08.16 00:00:01	59	USDCHF	buy	out	2.65	0,97864	59	0,00	- 18,99	-1 630,12	79 802,59
2020.12.02 00:00:00	60	USDCHF	sell	in	0.98	0,89917	60	0,00	0,00	0,00	79 802,59
2020.12.30 23:59:59	61	USDCHF	buy	out	0.98	0,88153	61	0,00	- 216,18	1 961,05	81 547,46

Table 4.5.4 – USD/CHF Transactions Report

## 4.6. BACK-TESTING USD/CAD

For the back-test of the USD/CAD pair strategy, the trading system processed 4.145 daily bars, containing the open, the low, the high, and the close prices of each trading day, and a total of 200.562.391 ticks. During this period, the alpha model emitted 42 entry signals, of which 24 signals were to open buy positions and 18 signals were to open sell positions. From the total of signals that the model triggered, the risk model rejected 10 of them or 23,8% over the total, and the broker rejected one trade due to the stop-loss size being higher than the limit authorized – i.e., on June 4th, 2017, a trade filled with 96,68 contracts. Excluding the rejections, the automated trade system could fill and execute 31 trades. Table 4.6.1 (USD/CAD Signals Triggered by the Alpha Model) details the dates each signal was triggered. It also shows if the risk model accepted or rejected the signals and the reasons for it.

i	date	signal	status	Commentary	i	date	signal	status	Commentary
1	21/09/2005	sell	approved		22	07/10/2011	buy	approved	
2	13/12/2005	sell	approved		23	01/12/2011	buy	rejected	SL rejected
3	08/03/2006	sell	rejected	SL rejected	24	21/12/2011	buy	rejected	SL rejected
4	01/05/2006	sell	approved		25	04/05/2013	buy	approved	
5	06/09/2006	sell	rejected	SL rejected	26	05/06/2013	buy	rejected	SL rejected
6	28/12/2006	buy	approved		27	02/07/2013	buy	approved	
7	18/06/2007	sell	rejected	SL rejected	28	09/09/2013	buy	rejected	SL rejected
8	11/07/2007	sell	approved		29	03/12/2013	buy	approved	
9	20/09/2007	sell	approved		30	02/01/2014	buy	approved	
10	25/06/2008	buy	rejected	SL rejected	31	12/12/2014	buy	approved	
11	06/08/2008	buy	approved		32	27/07/2015	buy	approved	
12	15/09/2008	buy	approved		33	29/09/2015	buy	approved	
13	14/10/2008	buy	approved		34	23/11/2015	buy	approved	
14	27/11/2008	buy	rejected	SL rejected	35	17/11/2016	buy	approved	
15	05/08/2009	sell	approved		36	01/05/2017	buy	approved	
16	15/10/2009	sell	approved		37	03/08/2017	sell	approved	
17	07/01/2010	sell	approved		38	01/09/2017	sell	approved	
18	15/03/2010	sell	approved		39	04/06/2017	buy	approved	Invalid Volume
19	22/12/2010	sell	rejected	SL rejected	40	06/01/2020	sell	approved	
20	07/01/2011	sell	approved		41	20/03/2020	buy	approved	
21	08/04/2011	sell	approved		42	04/05/2020	buy	approved	

Table 4.6.1 – USD/CAD Signals Triggered by the Model

The main reason for these rejections, as seen in table Figure 4.6.1 (Distances between Stop-loss Prices and Entry Prices of Rejected Trades for USD/CAD), was that the prices that the strategy set for the SL limit order for the trades were above entry price, in case of longs positions, and below the entry price, in case of short positions. Table 4.6.2 (USD/CAD Stop-loss Placement of the Rejected Trades) shows the rejected trades events with each entry price, the stop-loss limit order prices, and the distance between them. The distance between the stop-loss price and entry price was 242,8 pips, varying from negative 4,5 pips and negative 247,3 pips, with a mean at negative 98,1 pips. See Graph 4.6.1 (Distances between Stop-loss Prices and Entry Prices of Rejected Trades for USD/CAD).

Type	EP	SL	Diff.
Sell	1,1497	1,1397	-0,01
Sell	1,1222	1,1057	-0,0165
Sell	1,0679	1,0633	-0,0046
Buy	1,0125	1,0166	-0,0041
Buy	1,2324	1,2526	-0,0202
Sell	1,01724	1,00937	-0,00787
Buy	1,01907	1,0438	-0,02473
Buy	1,01947	1,0263	-0,00683
Sell	0,9885	0,98692	-0,00158
Buy	1,03406	1,03451	-0,00045
Buy	1,04053	1,05161	-0,01108

Table 4.6.2 – USD/CAD Distance between Stop-loss Prices and Entry Prices of Rejected Trades

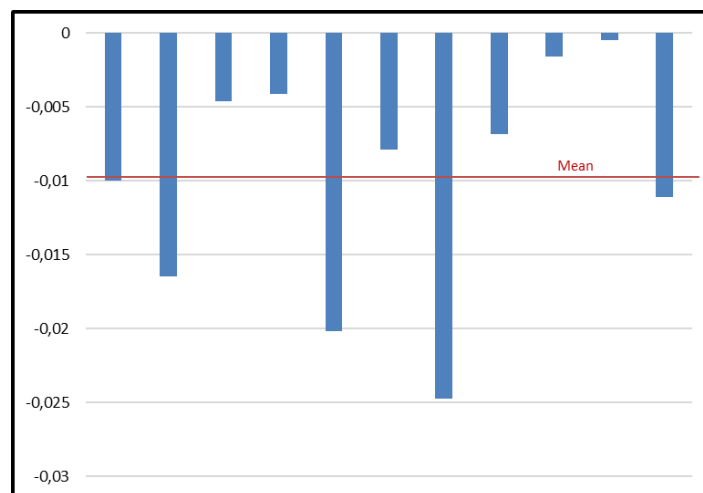


Figure 4.6.1 – USD/CAD Distance between Stop-loss Prices and Entry Prices of Rejected Trades

From Table 4.6.3 (USD/CAD Position Risk-Reward ratio (in pips)), one can observe that the highest risk-reward earned by the strategy was 6,69 earned per point risked, and the lowest was of negative -1.02. The average risk-reward ratio of this back-test sample was negative 0,42 pips. It means that for everyone monetary unit risked in a single trade, the automated trading system lost, on average, 0,42 monetary units.

Type	P&L	SL Size	RR	Type	P&L	SL Size	RR
sell	- 145,90	145	- 1,01	buy	- 27,40	27	- 1,01
sell	- 82,50	82	- 1,01	buy	- 39,90	39	- 1,02
sell	- 79,00	229	- 0,34	buy	- 2,50	122	- 0,02
buy	30,00	165	0,18	buy	-30,5	30,5	-1,00
sell	- 69,50	69	- 1,01	buy	933,6	139,6	6,69
sell	304,00	229	1,33	buy	-88,9	88,9	-1,00
buy	79,00	217	0,36	buy	-179	178,7	-1,00
buy	- 92,00	91	- 1,01	buy	-40,5	39,6	-1,02
buy	480,00	515	0,93	buy	-63	63	-1,00
sell	- 202,50	202	- 1,00	buy	-145,3	248,3	-0,59
sell	- 385,00	385	- 1,00	sell	-4,6	4,6	-1,00
sell	- 252,60	252	- 1,00	sell	1,1	60,8	0,02
sell	- 121,10	121	- 1,00	sell	-88,5	133,9	-0,66
sell	- 40,50	40	- 1,00	buy	-513,7	723,5	-0,71
sell	- 116,00	116	- 1,00	buy	-58,8	58,7	-1,00
buy	- 25,90	26	- 1,01				

Table 4.6.3 – USD/CAD Position Risk-Reward ratio (in pips)

The strategy delivered a total of 1.827,7 pips in profits and 2,895,1 pips in losses over the period tested, resulting in a net return of negative 1.067,4 pips. The trade that returned the highest loss was 513,7 pips, while the trade with the highest profit was 933,6. The average of pips lost per trade was negative 34,43 pips and a standard deviation of 243,7 pips. Moreover, the back-test for USD/CAD showed that from the 31 orders the execution model filled and executed, the stop-loss sizes vary from 4,6 pips to 723,5 pips. The stop-loss size samples presented a mean of 156,23 pips, a standard deviation of 150,79 pips, and a range of 718,9 pips. See Graph 4.6.2 – NZD/USD Position Information (in pips).

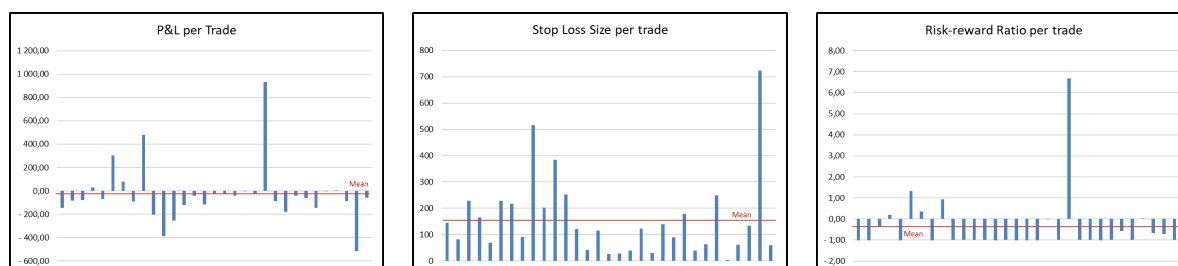
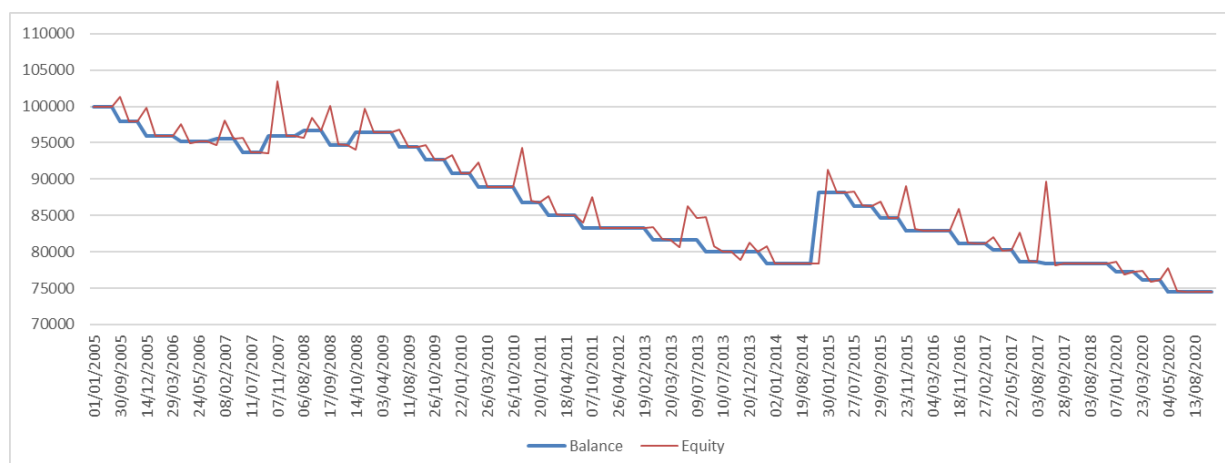


Figure 4.6.2 – USD/CAD Position Information (in pips)

The strategy generated 14.834,42 \$ in gains and 40.296,91 \$ in losses, resulting in a net loss of 25.462,49 \$ or a negative 26,27 return over the initial trading capital. The absolute balance drawdown of the account was 25.462,49 \$, or negative 25,46%, while the absolute equity drawdown was 25.462,49 \$ or 25,46%. Moreover, the simulation reached the maximal balance drawdown of 25.462,49 \$ or 25,46% and a maximal equity drawdown of 28.889,31 or 27,93%. See Figure 4.6.3 (USD/CAD Balance and Equity Evolution).



Graph 4.6.1 – USD/CAD Balance and Equity Evolution

Table 4.6.4 (USD/CAD Transactions Report below) details each transaction the trading system accomplished during the test. Of the 31 trades that the algorithm executed, 17 trades were longs, and 14 trades were shorts. However, five trades resulted in profits, and the remaining 26 trades resulted in losses. From these losses, the stop-loss limit order that the risk module set closed 20 trades, and the position management module closed prematurely five trades due to the trend condition no longer being valid. This result shows that the strategy had a win ratio over the back-testing period of 15,6%.

The largest profit-taken in trade was 9.729,55\$, with an average profit of 2.966,88\$. The most significant loss in trade was 2.079,99\$ with an average loss of 1.549,88\$. The position's maximal holding time was 1.176 hours, while the trade with the minimal holding duration of 2:01:24. The average duration of the trades was 267:03:35. Finally, the number of consecutive trades with profit in the test was two, totaling 3.019,72\$, and the number of consecutive losses was 11, totaling 18.007,25\$. See **Appendix C** of the supplementary electronic repository of this work for the complete output of the back-testing.

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2005.01.01 00:00:00	1		balance					0,00	0,00	100 000,00	100 000,00
2005.09.21 00:01:00	2	USDCAD	sell	in	1.61	1,16950	2	0,00	0,00	0,00	100 000,00
2005.10.05 21:17:27	3	USDCAD	buy	out	1.61	1,18409	3	0,00	- 96,20	-1 983,79	97 920,01
2005.12.13 00:01:00	4	USDCAD	sell	in	2.75	1,15110	4	0,00	0,00	0,00	97 920,01

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2005.12.15 14:58:24	5	USDCAD	buy	out	2.75	1,15935	5	0,00	- 47,76	-1 956,92	95 915,33
2006.05.01 00:02:00	6	USDCAD	sell	in	0.94	1,11750	6	0,00	0,00	0,00	95 915,33
2006.05.24 00:01:00	7	USDCAD	buy	out	0.94	1,12540	7	0,00	- 97,34	- 659,85	95 158,14
2006.12.28 00:00:30	8	USDCAD	buy	in	1.34	1,16190	8	0,00	0,00	0,00	95 158,14
2007.02.15 00:00:30	9	USDCAD	sell	out	1.34	1,16490	9	0,00	44,70	345,09	95 547,93
2007.07.11 00:00:00	10	USDCAD	sell	in	2.92	1,05430	10	0,00	0,00	0,00	95 547,93
2007.07.11 12:04:04	11	USDCAD	buy	out	2.92	1,06125	11	0,00	0,00	-1 912,27	93 635,66
2007.09.20 00:02:00	12	USDCAD	sell	in	0.83	1,01490	12	0,00	0,00	0,00	93 635,66
2007.11.20 00:00:30	13	USDCAD	buy	out	0.83	0,98450	13	0,00	- 251,89	2 562,93	95 946,70
2008.08.06 00:01:30	14	USDCAD	buy	in	0.92	1,04350	14	0,00	0,00	0,00	95 946,70
2008.08.29 00:19:30	15	USDCAD	sell	out	0.92	1,05140	15	0,00	17,41	691,27	96 655,38
2008.09.15 00:01:00	16	USDCAD	buy	in	2.26	1,06420	16	0,00	0,00	0,00	96 655,38
2008.09.19 15:29:36	17	USDCAD	sell	out	2.26	1,05500	17	0,00	10,15	-1 970,81	94 694,72
2008.10.14 00:00:00	18	USDCAD	buy	in	0.42	1,14660	18	0,00	0,00	0,00	94 694,72
2008.11.11 00:11:00	19	USDCAD	sell	out	0.42	1,19460	19	0,00	7,77	1 687,59	96 390,08
2009.08.05 00:00:00	20	USDCAD	sell	in	1.02	1,07304	20	0,00	0,00	0,00	96 390,08
2009.08.11 11:46:25	21	USDCAD	buy	out	1.02	1,09329	21	0,00	- 28,44	-1 889,25	94 472,39
2009.10.15 00:02:30	22	USDCAD	sell	in	0.5	1,02440	22	0,00	0,00	0,00	94 472,39
2009.10.26 17:05:39	23	USDCAD	buy	out	0.5	1,06290	23	0,00	- 21,59	-1 811,08	92 639,72
2010.01.07 00:00:00	24	USDCAD	sell	in	0.76	1,03241	24	0,00	0,00	0,00	92 639,72
2010.01.22 15:52:52	25	USDCAD	buy	out	0.76	1,05767	25	0,00	- 55,05	-1 815,08	90 769,59
2010.03.15 00:00:00	26	USDCAD	sell	in	1.52	1,01715	26	0,00	0,00	0,00	90 769,59
2010.03.26 14:19:34	27	USDCAD	buy	out	1.52	1,02926	27	0,00	- 97,06	-1 788,39	88 884,14
2011.01.07 00:00:00	28	USDCAD	sell	in	4.4	0,99657	28	0,00	0,00	0,00	88 884,14
2011.01.20 14:01:35	29	USDCAD	buy	out	4.4	1,00062	29	0,00	- 288,57	-1 780,90	86 814,67
2011.04.08 00:00:00	30	USDCAD	sell	in	1.44	0,95878	30	0,00	0,00	0,00	86 814,67
2011.04.18 16:57:40	31	USDCAD	buy	out	1.44	0,97038	31	0,00	- 59,96	-1 721,39	85 033,32
2011.10.07 00:00:00	32	USDCAD	buy	in	6.87	1,03804	32	0,00	0,00	0,00	85 033,32
2011.10.07 13:00:36	33	USDCAD	sell	out	6.87	1,03545	33	0,00	0,00	-1 718,41	83 314,91
2013.03.20 00:00:00	34	USDCAD	buy	in	6.29	1,02731	34	0,00	0,00	0,00	83 314,91
2013.03.20 11:09:38	35	USDCAD	sell	out	6.29	1,02457	35	0,00	0,00	-1 682,13	81 632,78
2013.07.02 00:00:00	36	USDCAD	buy	in	4.36	1,04970	36	0,00	0,00	0,00	81 632,78
2013.07.10 20:20:41	37	USDCAD	sell	out	4.36	1,04571	37	0,00	26,50	-1 663,60	79 995,68
2013.12.03 00:00:00	38	USDCAD	buy	in	1.39	1,06422	38	0,00	0,00	0,00	79 995,68
2013.12.26 08:00:00	39	USDCAD	sell	out	1.39	1,06397	39	0,00	22,99	- 32,66	79 986,01
2014.01.02 00:00:00	40	USDCAD	buy	in	5.58	1,06463	40	0,00	0,00	0,00	79 986,01
2014.01.02 15:14:29	41	USDCAD	sell	out	5.58	1,06158	41	0,00	0,00	-1 603,18	78 382,83
2014.12.12 00:00:00	42	USDCAD	buy	in	1.29	1,15201	42	0,00	0,00	0,00	78 382,83
2015.02.19 00:00:00	43	USDCAD	sell	out	1.29	1,24537	43	0,00	58,98	9 670,57	88 112,38
2015.07.27 00:05:00	44	USDCAD	buy	in	2.59	1,30407	44	0,00	0,00	0,00	88 112,38
2015.07.28 18:26:30	45	USDCAD	sell	out	2.59	1,29518	45	0,00	1,59	-1 777,75	86 336,22
2015.09.29 00:00:30	46	USDCAD	buy	in	1.29	1,33971	46	0,00	0,00	0,00	86 336,22
2015.10.01 17:00:00	47	USDCAD	sell	out	1.29	1,32181	47	0,00	3,10	-1 746,92	84 592,40
2015.11.23 00:03:00	48	USDCAD	buy	in	5.69	1,33293	48	0,00	0,00	0,00	84 592,40
2015.11.24 19:07:29	49	USDCAD	sell	out	5.69	1,32888	49	0,00	3,41	-1 734,13	82 861,68
2016.11.17 00:00:00	50	USDCAD	buy	in	3.54	1,34491	50	0,00	0,00	0,00	82 861,68
2016.11.21 17:36:59	51	USDCAD	sell	out	3.54	1,33861	51	0,00	4,19	-1 666,06	81 199,81
2017.05.01 00:01:30	52	USDCAD	buy	in	0.89	1,36587	52	0,00	0,00	0,00	81 199,81
2017.05.22 00:00:30	53	USDCAD	sell	out	0.89	1,35134	53	0,00	10,94	- 956,95	80 253,80
2017.08.03 00:15:00	54	USDCAD	sell	in	43.87	1,25715	54	0,00	0,00	0,00	80 253,80
2017.08.03 02:16:24	55	USDCAD	buy	out	43.87	1,25761	55	0,00	0,00	-1 604,65	78 649,15
2017.09.01 00:16:00	56	USDCAD	sell	in	3.23	1,24783	56	0,00	0,00	0,00	78 649,15
2017.09.28 00:00:00	57	USDCAD	buy	out	3.23	1,24772	57	0,00	- 354,99	28,48	78 322,64
2020.01.06 00:00:00	58	USDCAD	sell	in	1.52	1,29861	58	0,00	0,00	0,00	78 322,64
2020.01.22 00:00:00	59	USDCAD	buy	out	1.52	1,30746	59	0,00	- 93,22	-1 028,87	77 200,55
2020.03.20 00:00:00	60	USDCAD	buy	in	0.31	1,45050	60	0,00	0,00	0,00	77 200,55
2020.04.08 00:00:00	61	USDCAD	sell	out	0.31	1,39913	61	0,00	2,98	-1 138,19	76 065,34
2020.05.04 00:00:00	62	USDCAD	buy	in	3.65	1,40872	62	0,00	0,00	0,00	76 065,34
2020.05.05 15:04:38	63	USDCAD	sell	out	3.65	1,40284	63	0,00	2,07	-1 529,90	74 537,51

Table 4.6.4 – USD/CAD Transactions Report

#### 4.7. BACK-TESTING USD/JPY

For back-testing the USD/JPY pair, the trading system processed 4.143 daily bars, containing the open, the low, the high, and the close prices of each trading day, and a total of 230.699.349 ticks. During this period, the alpha model emitted 51 entry signals, of which 22 signals were to open buy positions and 29 were to open sell positions. From the total of signals that the model triggered, the risk model rejected 13 of them or 25,5% over the total. Excluding the rejections, the automated trade system was able to fill and execute 38 trades. Table 4.7.1 (USD/JPY Signals Triggered by the Alpha Model) shows the dates each signal was triggered. It also shows if the risk model accepted or rejected the signals and the reason for it.

i	date	signal	status	Commentary	i	date	signal	status	Commentary
1	05/01/2005	sell	rejected	SL rejected	27	30/09/2014	buy	approved	
2	25/01/2005	sell	approved		28	06/11/2014	buy	approved	
3	20/06/2005	buy	approved		29	07/01/2015	buy	rejected	SL rejected
4	05/10/2005	buy	approved		30	06/03/2015	buy	approved	
5	19/10/2006	buy	rejected	SL rejected	31	29/05/2015	buy	approved	
6	06/06/2007	buy	approved		32	12/08/2015	buy	approved	
7	13/11/2007	sell	approved		33	17/02/2016	sell	approved	
8	24/01/2008	sell	approved		34	25/03/2016	sell	rejected	SL rejected
9	07/03/2008	sell	approved		35	12/05/2016	sell	rejected	SL rejected
10	03/12/2008	sell	approved		36	21/06/2016	sell	approved	
11	26/01/2009	sell	approved		37	10/08/2016	sell	rejected	SL rejected
12	02/10/2009	sell	approved		38	27/09/2016	sell	approved	
13	27/11/2009	sell	approved		39	06/01/2017	buy	rejected	SL rejected
14	26/08/2010	sell	approved		40	14/07/2017	buy	approved	
15	08/10/2010	sell	approved		41	14/09/2017	sell	rejected	SL rejected
16	13/05/2011	sell	rejected	SL rejected	42	26/09/2018	buy	approved	
17	13/06/2011	sell	approved		43	08/11/2018	buy	approved	
18	20/07/2011	sell	approved		44	17/06/2019	sell	approved	
19	01/11/2011	sell	rejected	SL rejected	45	12/08/2019	sell	approved	
20	20/03/2012	buy	approved		46	29/01/2020	buy	rejected	SL rejected
21	12/09/2012	sell	approved		47	20/02/2020	buy	approved	
22	02/01/2013	buy	approved		48	24/07/2020	sell	approved	
23	18/03/2013	buy	rejected	SL rejected	49	23/09/2020	sell	approved	
24	16/04/2013	buy	rejected	SL rejected	50	28/10/2020	sell	approved	
25	17/05/2013	buy	approved		51	01/12/2020	sell	approved	
26	04/12/2013	buy	approved						

Table 4.7.1 – USD/JPY Signals Triggered by the Alpha Model

The sole reason for these rejections, as seen in table Graph 4.7.1 - Distances between Stop-loss Prices and Entry Prices of Rejected Trades for USD/JPY, was that the prices that the strategy set for the SL limit order for the trades were above entry price, in case of longs positions, and below the entry price, in case of short positions. Table 4.7.2 (USD/JPY Stop-loss Placement of the Rejected Trades) shows the rejected trades events with each entry price, the stop-loss limit order prices, and the distance between them. The distance between the stop-loss price and entry price was 193,2 pips, varying from negative 7,3 pips and negative 200,5 pips, with a mean at negative 0,823 pips. See Graph 4.7.1 (Distances between Stop-loss Prices and Entry Prices of Rejected Trades for USD/JPY).

Type	EP	SL	Diff.
Sell	104,46	104,25	-0,21
Buy	118,92	119,25	-0,33
Sell	80,988	80,915	-0,073
Sell	78,107	76,282	-1,825
Buy	94,896	95,962	-1,066
Buy	96,582	98,587	-2,005
Buy	118,402	118,862	-0,46
Sell	112,819	111,753	-1,066
Sell	108,391	107,495	-0,896
Sell	101,849	101,567	-0,282
Buy	115,378	116,037	-0,659
Sell	110,475	109,271	-1,204
Buy	109,186	109,82	-0,634

Table 4.7.2 – USD/JPY Distance between Stop-loss Prices and Entry Prices of Rejected Trades

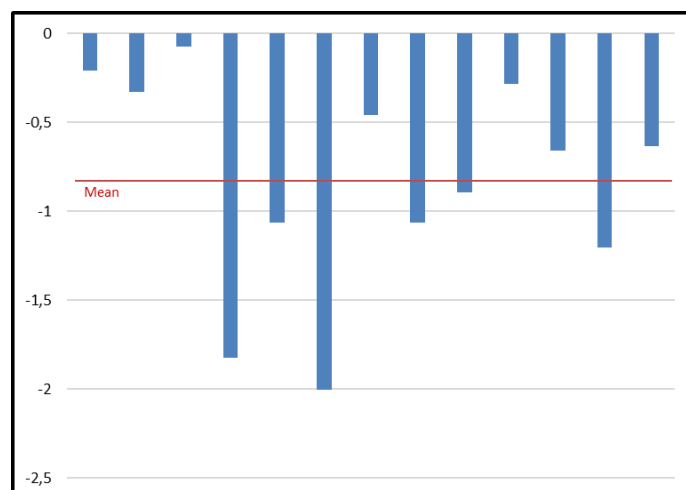


Figure 4.7.1 – USD/JPY Distance between Stop-loss Prices and Entry Prices of Rejected Trades

In Table 4.7.3 (USD/JPY Position Risk-Reward ratio (in pips)) below, one can observe that the highest risk-reward earned by the strategy was 3,56 earned per point risked, and the lowest was negative

1,03. The automated trading system managed to lose, on average, 0,52 monetary units for every monetary unit risked in a single trade.

Type	P&L	SL Size	RR	Type	P&L	SL Size	RR
sell	-36	36	- 1,00	buy	213,20	125	1,70
buy	-51	51	- 1,00	buy	- 120,00	120	- 1,00
buy	122,00	148	0,82	buy	479,80	598	0,80
buy	- 139,00	139	- 1,00	buy	-102,1	102	-1,00
buy	- 9,00	9	- 1,00	buy	-103	332,3	-0,31
sell	- 208,00	523	- 0,40	buy	-113,8	113,7	-1,00
sell	- 128,30	128	- 1,00	sell	140,3	119	1,18
sell	79,00	282	0,28	sell	-253	252,9	-1,00
sell	- 32,00	278	- 0,12	sell	-176,9	176,2	-1,00
sell	- 290,60	289	- 1,01	buy	-20,5	20,5	-1,00
sell	- 178,00	178	- 1,00	buy	-81	80,9	-1,00
sell	- 272,60	271,9	- 1,00	buy	-94,3	94,3	-1,00
sell	- 132,40	132	- 1,00	sell	-23,2	23,2	-1,00
sell	- 22,20	127,3	- 0,17	sell	-110,6	110,6	-1,00
sell	- 9,50	9,4	- 1,01	buy	-182,1	177	-1,03
sell	- 41,40	41,3	- 1,00	sell	18,2	50,4	0,36
buy	- 143,40	143,3	- 1,00	sell	-55,8	55,8	-1,00
sell	-73,2	73,2	- 1,00	sell	-106,6	106,5	-1,00
buy	543,2	152,4	3,56	sell	-48,4	48,3	-1,00
buy	-169,2	169,2	- 1,00				

Table 4.7.3 – USD/JPY Position Risk-Reward ratio (in pips)

The strategy delivered a total of 1.595,7 pips in profits and 3.527,1 pips in losses over the period tested, resulting in a net return of negative 1.931,4 pips. The trade that returned the highest loss was 290,6 pips, while the trade with the highest profit was 543,2 pips. The average of pips lost per trade was negative 49,52 pips and a standard deviation of 166,98 pips. Moreover, the back-test for USD/JPY showed that from the 39 orders the execution model filled and executed, the stop-loss sizes vary from 9 pips to 598,4 pips. The stop-loss size samples presented a mean of 150,98 pips, a standard deviation of 125,64 pips, and a range of 589,4 pips. See Graph 4.7.2 – NZD/JPY Position Information (in pips).

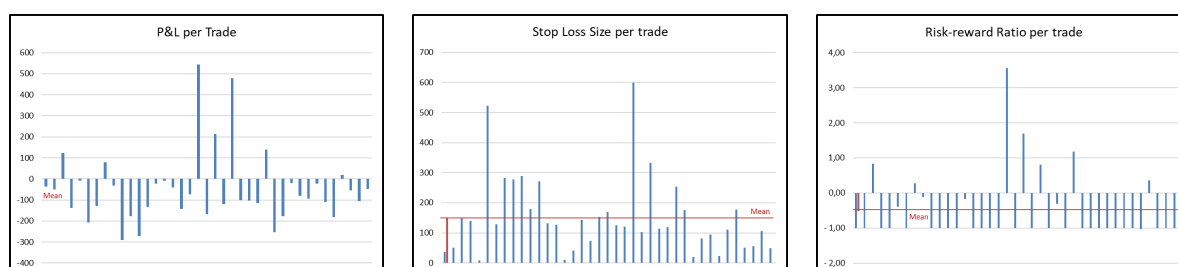


Figure 4.7.2 – USD/JPY Position Information (in pips)

The strategy generated 12.377,81\$ in gains and 49.459,78\$ in losses, resulting in a net loss of 37.081,97\$ or a negative 37,1% return over the initial trading capital. The absolute balance drawdown of the account was 37.081,97\$, or negative 37,1%, while the absolute equity drawdown was 37.081,97\$ or 37,1%. Moreover, the simulation reached the maximal balance drawdown of



37.081,97\$ or 37,1%, and a maximal equity drawdown of 41.741,29 or 39,9%. Figure 4.7.3 (USD/JPY Balance and Equity Evolution) displays the information below.

Table 4.7.4 (USD/JPY Transactions Report) details each trading system's transaction accomplished during the test. Of the 39 trades that the algorithm executed, 17 trades were longs, and 22 were shorts. Nevertheless, six trades resulted in profits, and the remaining 33 trades resulted in losses. From these losses, the stop-loss limit order that the risk module set closed 29 trades, and the position management module closed prematurely three trades due to the trend condition no longer being valid. This result shows that the strategy had a win ratio over the back-testing period of 15,8%.

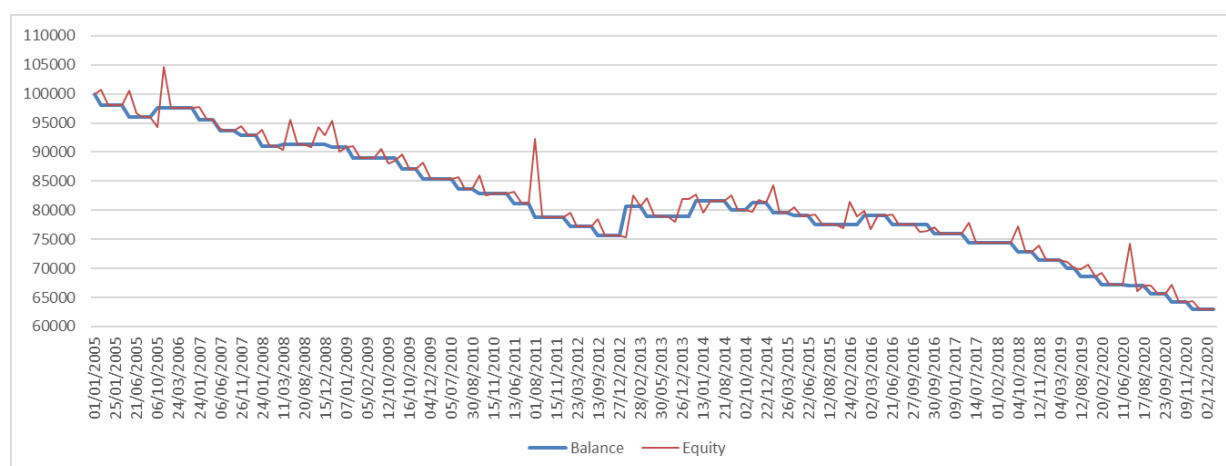


Figure 4.7.3 – USD/JPY Balance and Equity Evolution

The most significant profit-taking in trade was 5.069,46\$, with an average profit of 2.062,97\$. The most considerable loss in trade was 2.351,37\$, with an average loss of 1.498,78\$. The position's maximal holding time was 1.272 hours, while the trade with the minimal holding duration of less than two seconds. The average duration of the trades was 259:48:22 hours. Finally, the number of consecutive trades with profit in the test was 1, totalizing 5.069,46\$, and the number of consecutive losses was 12, totalizing 16.160,57\$. See **Appendix C** of the supplementary electronic repository of this work for the complete output of the back-testing.

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2005.01.01 00:00:00	1		balance						0,00	100 000,00	100 000,00
2005.01.25 00:01:00	2	USDJPY	sell	in	5.7	102,660	2	0,00	0,00	0,00	100 000,00
2005.01.25 07:41:33	3	USDJPY	buy	out	5.7	103,020	3	0,00	0,00	-1 991,85	98 008,15
2005.06.20 00:01:00	4	USDJPY	buy	in	4.19	108,950	4	0,00	0,00	0,00	98 008,15
2005.06.21 16:49:40	5	USDJPY	sell	out	4.19	108,440	5	0,00	0,19	-1 970,58	96 037,76
2005.10.05 00:01:00	6	USDJPY	buy	in	1.48	114,350	6	0,00	0,00	0,00	96 037,76
2005.12.19 00:01:00	7	USDJPY	sell	out	1.48	115,570	7	0,00	4,62	1 562,34	97 604,72
2007.01.24 00:00:00	8	USDJPY	buy	in	1.71	121,710	8	0,00	0,00	0,00	97 604,72
2007.01.25 06:01:34	9	USDJPY	sell	out	1.71	120,320	9	0,00	0,21	-1 975,48	95 629,45
2007.06.06 00:00:30	10	USDJPY	buy	in	25.79	121,380	10	0,00	0,00	0,00	95 629,45
2007.06.06 00:58:13	11	USDJPY	sell	out	25.79	121,290	11	0,00	0,00	-1 913,68	93 715,77

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2007.11.13 00:00:00	12	USDJPY	sell	in	0.39	109,540	12	0,00	0,00	0,00	93 715,77
2007.12.10 00:01:00	13	USDJPY	buy	out	0.39	111,620	13	0,00	103,34	- 726,75	92 885,68
2008.01.24 00:00:30	14	USDJPY	sell	in	1.55	106,600	14	0,00	0,00	0,00	92 885,68
2008.01.25 09:25:36	15	USDJPY	buy	out	1.55	107,883	15	0,00	- 15,62	-1 843,34	91 026,72
2008.03.07 00:00:00	16	USDJPY	sell	in	0.66	102,540	16	0,00	0,00	0,00	91 026,72
2008.04.07 00:00:30	17	USDJPY	buy	out	0.66	101,750	17	0,00	205,78	512,43	91 333,37
2008.12.03 00:00:00	18	USDJPY	sell	in	0.61	93,150	18	0,00	0,00	0,00	91 333,37
2009.01.07 00:00:00	19	USDJPY	buy	out	0.61	93,470	19	0,00	253,01	- 208,84	90 871,52
2009.01.26 00:00:00	20	USDJPY	sell	in	0.56	88,400	20	0,00	0,00	0,00	90 871,52
2009.02.05 18:05:26	21	USDJPY	buy	out	0.56	91,306	21	0,00	- 80,93	-1 782,31	89 008,28
2009.10.02 00:01:30	22	USDJPY	sell	in	0.9	89,560	22	0,00	0,00	0,00	89 008,28
2009.10.16 14:29:13	23	USDJPY	buy	out	0.9	91,340	23	0,00	152,35	-1 753,89	87 102,04
2009.11.27 00:00:00	24	USDJPY	sell	in	0.55	86,408	24	0,00	0,00	0,00	87 102,04
2009.12.04 14:30:40	25	USDJPY	buy	out	0.55	89,134	25	0,00	- 47,65	-1 682,07	85 372,32
2010.08.26 00:00:30	26	USDJPY	sell	in	1.09	84,588	26	0,00	0,00	0,00	85 372,32
2010.08.30 03:49:59	27	USDJPY	buy	out	1.09	85,912	27	0,00	- 27,74	-1 679,81	83 664,77
2010.10.08 00:00:00	28	USDJPY	sell	in	1.08	82,296	28	0,00	0,00	0,00	83 664,77
2010.11.15 00:00:00	29	USDJPY	buy	out	1.08	82,518	29	0,00	515,34	- 290,55	82 858,88
2011.06.13 00:00:00	30	USDJPY	sell	in	14.15	80,292	30	0,00	0,00	0,00	82 858,88
2011.06.13 01:16:02	31	USDJPY	buy	out	14.15	80,387	31	0,00	0,00	-1 672,22	81 186,66
2011.07.20 00:00:00	32	USDJPY	sell	in	3.11	79,154	32	0,00	0,00	0,00	81 186,66
2011.08.04 09:25:27	33	USDJPY	buy	out	3.11	79,568	33	0,00	733,21	-1 618,16	78 835,29
2012.03.20 00:00:00	34	USDJPY	buy	in	0.92	83,394	34	0,00	0,00	0,00	78 835,29
2012.03.29 15:18:28	35	USDJPY	sell	out	0.92	81,960	35	0,00	0,63	-1 609,66	77 226,26
2012.09.12 00:00:00	36	USDJPY	sell	in	1.64	77,796	36	0,00	0,00	0,00	77 226,26
2012.09.17 14:55:39	37	USDJPY	buy	out	1.64	78,528	37	0,00	113,69	-1 528,73	75 583,84
2013.01.02 00:00:00	38	USDJPY	buy	in	0.86	86,771	38	0,00	0,00	0,00	75 583,84
2013.02.28 00:00:00	39	USDJPY	sell	out	0.86	92,203	39	0,00	2,90	5 066,56	80 653,30
2013.05.17 00:00:00	40	USDJPY	buy	in	0.97	102,230	40	0,00	0,00	0,00	80 653,30
2013.05.30 08:29:15	41	USDJPY	sell	out	0.97	100,538	41	0,00	0,63	-1 632,46	79 021,47
2013.12.04 00:00:00	42	USDJPY	buy	in	1.29	102,438	42	0,00	0,00	0,00	79 021,47
2014.01.16 00:00:00	43	USDJPY	sell	out	1.29	104,570	43	0,00	2,75	2 630,09	81 654,31
2014.09.30 00:00:00	44	USDJPY	buy	in	1.49	109,451	44	0,00	0,00	0,00	81 654,31
2014.10.02 17:40:16	45	USDJPY	sell	out	1.49	108,251	45	0,00	0,28	-1 651,72	80 002,87
2014.11.06 00:00:00	46	USDJPY	buy	in	0.31	114,727	46	0,00	0,00	0,00	80 002,87
2014.12.22 00:00:00	47	USDJPY	sell	out	0.31	119,525	47	0,00	0,50	1 244,41	81 247,78
2015.03.06 00:00:00	48	USDJPY	buy	in	1.91	120,135	48	0,00	0,00	0,00	81 247,78
2015.03.26 06:17:14	49	USDJPY	sell	out	1.91	119,114	49	0,00	1,60	-1 637,18	79 612,20
2015.05.29 00:00:00	50	USDJPY	buy	in	0.59	123,957	50	0,00	0,00	0,00	79 612,20
2015.06.22 00:05:00	51	USDJPY	sell	out	0.59	122,927	51	0,00	0,47	- 494,36	79 118,31
2015.08.12 00:00:30	52	USDJPY	buy	in	1.74	125,151	52	0,00	0,00	0,00	79 118,31
2015.08.12 15:23:27	53	USDJPY	sell	out	1.74	124,013	53	0,00	0,00	-1 596,70	77 521,61
2016.02.17 00:00:00	54	USDJPY	sell	in	1.49	114,065	54	0,00	0,00	0,00	77 521,61
2016.03.09 00:00:00	55	USDJPY	buy	out	1.49	112,662	55	0,00	298,53	1 855,52	79 078,60
2016.06.21 00:00:00	56	USDJPY	sell	in	0.65	103,888	56	0,00	0,00	0,00	79 078,60
2016.06.24 00:05:38	57	USDJPY	buy	out	0.65	106,418	57	0,00	- 33,48	-1 545,32	77 499,80
2016.09.27 00:00:00	58	USDJPY	sell	in	0.88	100,298	58	0,00	0,00	0,00	77 499,80
2016.10.04 03:54:32	59	USDJPY	buy	out	0.88	102,067	59	0,00	- 65,92	-1 525,19	75 908,69
2017.07.14 00:04:01	60	USDJPY	buy	in	8.39	113,305	60	0,00	0,00	0,00	75 908,69
2017.07.14 14:50:29	61	USDJPY	sell	out	8.39	113,100	61	0,00	0,00	-1 520,73	74 387,96
2018.09.26 00:01:00	62	USDJPY	buy	in	2.08	112,966	62	0,00	0,00	0,00	74 387,96
2018.10.11 00:12:35	63	USDJPY	sell	out	2.08	112,156	63	0,00	1,55	-1 502,19	72 887,32
2018.11.08 00:00:00	64	USDJPY	buy	in	1.76	113,545	64	0,00	0,00	0,00	72 887,32
2018.11.19 17:04:15	65	USDJPY	sell	out	1.76	112,602	65	0,00	0,71	-1 473,93	71 414,10
2019.06.17 00:00:00	66	USDJPY	sell	in	6.68	108,475	66	0,00	0,00	0,00	71 414,10
2019.06.17 00:00:02	67	USDJPY	buy	out	6.68	108,707	67	0,00	0,00	-1 425,63	69 988,47
2019.08.12 00:00:00	68	USDJPY	sell	in	1.32	105,567	68	0,00	0,00	0,00	69 988,47
2019.08.13 00:00:01	69	USDJPY	buy	out	1.32	106,673	69	0,00	- 13,53	-1 368,59	68 606,35
2020.02.20 00:00:00	70	USDJPY	buy	in	0.86	111,380	70	0,00	0,00	0,00	68 606,35

Time	Deal	Symbol	Type	Direction	Volume	Price	Order	Commission	Swap	Profit	Balance
2020.02.27 23:00:21	71	USDJPY	sell	out	0.86	109,559	71	0,00	0,28	-1 429,42	67 177,21
2020.07.24 00:00:00	72	USDJPY	sell	in	2.85	106,851	72	0,00	0,00	0,00	67 177,21
2020.08.17 00:02:30	73	USDJPY	buy	out	2.85	106,669	73	0,00	639,75	486,27	67 023,73
2020.09.23 00:00:00	74	USDJPY	sell	in	2.52	104,871	74	0,00	0,00	0,00	67 023,73
2020.09.23 19:59:26	75	USDJPY	buy	out	2.52	105,429	75	0,00	0,00	-1 333,75	65 689,98
2020.10.28 00:00:00	76	USDJPY	sell	in	1.29	104,458	76	0,00	0,00	0,00	65 689,98
2020.11.09 18:10:32	77	USDJPY	buy	out	1.29	105,524	77	0,00	-	-1 303,15	64 226,55
2020.12.01 00:00:00	78	USDJPY	sell	in	2.77	104,270	78	0,00	160,28	0,00	64 226,55
2020.12.02 14:32:32	79	USDJPY	buy	out	2.77	104,754	79	0,00	- 28,68	-1 279,84	62 918,03

Table 4.7.4 – USD/JPY Transactions Report

## 4.8. SUMMARY OF EMPIRICAL RESULTS DISCUSSION

This study aimed to develop a fully automated trading system from the Perfect Order Strategy premises (Lien, 2015) described in her book “Day Trading the Currency Market.” The back-test executed the strategy in seven U.S. based currency pairs, i.e., EUR/USD, GBP/USD, AUD/USD, NZD/USD, USD/CAD, USD/CHF, and USD/JPY, with an initial capital of 100.000\$ for each simulation, totalizing 700.000\$. Furthermore, during 5.843 days (16.2 years), the database fed the model with 1.498.832.507 ticks converted in 29.005 daily bars.

	GBPUSD	EURUSD	AUDUSD	NZDUSD	USDCHF	USDCAD	USDJPY
<b>Data</b>							
Total bars	4 436	4 144	4 144	4 143	4 143	4 145	4 143
Total ticks	250 559 363	243 396 744	208 478 112	173 714 967	191 421 581	200 562 391	230 699 349
<b>Signals</b>							
Total signals	56	52	60	62	50	42	51
Approved signals	32	36	40	40	30	32	38
Rejected signals	24	16	20	22	20	10	13
<b>Summary of trades (in pips)</b>							
Total gains	4 475,3	4 010,2	1 670,5	1 625,0	1 695,0	1 827,7	1 595,7
Total losses	-2 894,0	-2 371,7	-2 338,1	-2 671,5	-2 367,3	-2 895,1	-3 527,1
Net result from gains and losses	1 581,3	1 638,5	-667,6	-1 046,5	-672,3	-1 067,4	-1 931,4
Best trade	2 726,0	862,9	762,0	401,5	405,0	933,6	543,2
Worst trade	-450,2	-251,2	-268,7	-239,7	-222,9	-513,7	-290,6
Average result from best and worst trades	51,0	49,7	-17,6	-27,5	-22,4	-34,4	-49,5
Best Risk-reward	10,99	37,59	4,96	4,08	3,97	6,69	3,56
Worst Risk-reward	-1,04	-1,42	-1,02	-1,03	-1,03	-1,02	-1,03
Average Risk-reward	0,24	1,20	-1,00	-0,36	-0,28	-0,42	-0,52
Stop-loss min. range	4,8	7,8	11,9	7,6	21,0	4,6	9,0
Stop-loss max. range	551,3	420	925,0	380,9	500	723,5	598,40
Average Stop-loss range	209,5	209,5	103,6	120,6	147,1	156,2	150,98
<b>Summary of Results (in \$)</b>							
Total gains	51 968,07	130 293,90	24 408,27	21 103,14	19 191,80	14 834,42	12 377,81
Total losses	-39 852,10	-51 503,87	-45 047,71	-47 375,96	-37 644,34	-40 296,91	-49 459,78
Net result from gains and losses	12 115,97	78 790,03	-20 639,44	-26 272,82	-18 452,54	-25 462,49	-37 081,97
Absolute balance drawdown	7 896,00	6 555,06	28 270,82	31 600,83	20 197,41	25 462,49	37 081,97
Maximal balance drawdown	15 258,06	19 361,71	28 458,02	36 467,81	23 106,08	25 492,49	37 081,97
Absolute equity drawdown	8 922,38	8 102,66	29 421,07	32 290,84	20 443,11	25 462,49	37 081,97
Maximal equity drawdown	39 619,54	47 464,47	41 081,91	41 445,40	33 426,50	28 889,31	41 741,19
Total trades	31	33	38	38	30	31	39
Longs	17	15	18	18	11	17	17
Shorts	14	18	20	20	19	14	22

	GBPUSD	EURUSD	AUDUSD	NZDUSD	USDCHF	USDCAD	USDJPY
Winning trades	9	11	9	8	9	5	6
Losing Trades	22	22	29	30	21	17	33
Win rate	0,29	0,333	0,237	0,211	0,300	0,161	0,154
Best trade (\$)	20 990,20	73 873,76	7 743,30	5 575,64	6 235,20	9 729,55	5 069,46
Average profits (\$)	5 774,23	11 844,90	2 712,03	2 637,89	2 132,42	2 966,88	2 062,97
Worst Trade (\$)	-2 521,12	-4 553,82	-2 005,40	-2 113,92	-2 135,56	-2 079,99	-2 351,37
Average losses (\$)	-1 811,46	-2 341,09	-1 553,37	-1 579,20	-1 792,59	-1 549,88	-1 498,78
Longest position duration	1584:00:00	1320:00:30	1224:00:00	1104:00:00	840:00:00	1176:00:00	1272:00:00
Shortest position duration	0:03:27	0:00:01	4:15:29	360:00:00	00:43:44	2:01:24	0:00:02
Average position duration	346:24:46	411:02:28	258:26:17	270:38:00	278:36:28	267:03:35	259:48:22
Max. Consecutive wins	3	1	2	2	2	2	1
Max. Consecutive gains (\$)	24 619,20	23 930,41	7 631,38	8 118,43	5 973,97	3 019,72	5 069,46
Max. Consecutive trades w/ losses	7	4	11	13	6	11	12
Max. Consecutive loss (\$)	-14 609,06	-16 126,82	-14 832,05	-24 546,86	-9 057,74	-18 007,25	-16 160,57
Average consecutive wins	2	1	1	1	1	1	1
Average consecutive losses	4	2	4	5	3	5	3

Table 4.8.1 – All pairs back-testing summary results

The automated system generated 373 signals over the tested period, of which 181 were long signals, and 192 were short signals. From this total, the Risk model accepted 247 signals and rejected the remained 126. Notably, data shows that 100% of the rejections were due to a misplaced stop-loss limit order. The stop-loss rule, that dictates that the stop-loss limit order should be set as the low of the fifth daily candle after the entry signal that the Alpha model triggered in a long position and the high of the fifth candle (in the same condition) in a short position, caused the Risk model to attempt to place the stop-loss limit order prices above the entry prices for buy positions and below the entry prices for sell positions. This event created negative values, or range, between the entry price and the stop-loss limit order raising a red flag for a critical error and provoking the Risk model to reject the trade.

Also, the broker rejected an additional seven trades because the contract size that the Risk model calculated for these positions was larger than 50 lots, which is the maximum lot size the broker allows per single trade. Once the Execution model filled the order with the invalid lot size and sent it to the broker, he rejected it.

Over the period, the algorithm generated 16.899,4 pips in profits and 19.064,8 pips in losses, resulting in a net loss of 2.165,4. This negative result in pips, however, contrasts with the 38.285,42\$ in profits the strategy delivered. It explains due to one single position that the automated system traded in EUR/USD on August 18th, 2014, and lasted 63 days, that generated the substantial amount of 73.873,76\$ in profits alone, raising the profit per pip average to 8,012\$, while the losses per pip average were 5.945\$. One can attest that by taking out the referred trade from the sample, the profit per pip average is lower than 3,78\$, aligning with the overall result of the sample.

Verifying the data from the sample, one can perceive that on numerous occasions, many positions that ended in loss spent some time of its trading cycle in profit. An example is the back-testing realized with USD/JPY pair, which proves that a position opened on June 20th, 2005, resulted in a loss of 1.970,58\$, but reached a temporary profit of 13.439,17\$ throughout

the trade. Another example is a position in the same pair as the previous example that reached 7.054,5\$ in profit but ended with a loss. The AUD/USD data give us another two examples, among several others: on November 25th, 2008, the trading system holds a position that reached 17.769,07\$ in profits but ended with 1.923,57\$ in loss; and on May 2nd, 2011, another position reached 14.112,84\$ in profit too, afterward, hit the stop-loss limit order and generate a loss of 1.150,2\$.

Finally, although the strategy achieved a poor win rate of 23,8%, the risk management of the positions played a fundamental role in preserving the account capital. As one can attest, data demonstrates that, when analyzing only positions that ended in losses, the losing positions lost the amount the Risk model allowed them to lose, providing an average risk-reward ratio of -1,08 for losing positions, which is reasonably close to the optimal value of negative 1. Moreover, two losses were responsible for raising the average risk-reward ratio, with one position opened on June 3rd, 2019, with a risk-reward ratio of 1,3. Another position opened on September 13th, 2019, with a risk-reward ratio of 1,4. a slippage event created by a gap formed between the previous day's close price and the opening price of the current day that caused this excess, catching the stop-loss limit order in the middle of the range.

At its core, the strategy showed a solid model to identify trends in its early stage. However, notwithstanding the positive monetary result obtained from the back-testing, evidence shows that the rules that the author of the strategy established for stop-loss placement and the profit target event are deficient. Although the Perfect Order Strategy shows to be a promising strategy, in the current state and characteristic it is, the strategy is fragile and inefficient. We are confident that additional research to improve the stop-loss allocation rule and the take profit procedure rule could bring the strategy to raise its win ratio and, consequently, its result.

## 5. CONCLUSIONS, STUDY LIMITATIONS, AND FUTURE RESEARCH

Our research concludes that the Perfect Order is a promising strategy capable of identifying trends in its early stage; however, data showed the stop-loss limit order placement and the taking profit procedures are flawed. According to the results, these flaws were partly responsible for the low winning rate of the strategy. For instance, when we look at the balance and equity evolution figures of the back-tested pairs, it is evident that several positions the automated systems traded were in profits before closing it in losses. This finding led us to conclude that the strategy failed to lock part of or totality of the profits. See Figures 4.1.3, 4.2.3, 4.3.3, 4.4.3, 4.5.3, 4.6.3, and 4.7.3.

Another example is when one looks at the trades that the risk model rejected because the stop-loss limit order prices were negative in relation to the entry price. Moreover, of the trades that were accepted, some stop-loss limit order prices were so close to the entry price that the positions were closed immediately after the trading system executed the order. On the other side of the spectrum, some stop-loss limit orders were so far from the entry price that a very long and steady trend would be necessary to overcome the risk taken for that trade. Refer to Tables 4.1.2, 4.2.2, 4.3.2, 4.4.2, 4.5.2, 4.6.2, and 4.7.2.

Notwithstanding the positive return, the strategy performed below the S&P500 index over the same period in the long run. Although the strategy presented decisive weakness with an average win rate of 24%, we believe the automated trading system played an essential role in limiting losses and protecting the investment capital. Data indicates how losses and the risk taken by the Risk model of the FX pairs' back-testing were consistent throughout the period. This consistency was translated in controlled drawdowns over the period.

We find that the Perfect Order Strategy demonstrates to be a promising strategy. However, in the current state and characteristic it is, the strategy is fragile and unprofitable. We point to two procedures that the researcher could investigate to improve the strategy's profitability: the stop-loss limit order rule, the take-profit rule. As an attempt to help those who may want to deepen in the strategy, we suggest that the investigator could, for example, search for techniques or models that can train the stop-loss limit order rule to avoid extreme values or that could develop a better stop-loss limit order placement so that the number of rejected trades can be diminished.

For the take-profit procedure, the trader/investigator could search for models or techniques that, at some point in the position, could start closing part of the position until the end of the trend.

We are confident that additional research over the stop-loss limit order and the take-profit procedures could help improve the winning rate probability of the strategy and, consequently, its overall result.

## REFERENCES

- Bank for International Settlement. (2019). *Triennial Central Bank Survey Foreign exchange turnover in April 2019* (p. 23). Bank for International Settlement.
- <https://www.bis.org/statistics/rpfx19.htm>
- Basso, T. (2019). *Successful Traders Size Their Positions – Why and How?* (1st ed.). enjoytheride.world LLC.
- Burns, B. (2014). *Trend Trading for Dummies*. John Wiley & Sons.
- C++ Core Guidelines. (2021, June 17). *Standard C++ Foundation*.
- <http://isocpp.github.io/CppCoreGuidelines/CppCoreGuidelines>
- Chan, E. P. (2009a). *Quantitative trading: How to build your own algorithmic trading business*. Wiley trading series.
- Chan, E. P. (2009b). *Quantitative trading: How to build your own algorithmic trading business*. Wiley trading series.
- Chen, J. (2021, February). Currency Pair. *Investopedia*.
- <https://www.investopedia.com/terms/c/currencypair.asp>
- Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2009). *Introduction to algorithm* (3rd edition).
- Cory, M. (2021, April 29). How to Use a Moving Average to Buy Stocks. *Investopedia*.
- <https://www.investopedia.com/articles/active-trading/052014/how-use-moving-average-buy-stocks.asp>
- European Central Bank. (2019). European Central Bank: Banking Supervision. *Algorithmic Trading: Trends and Existing Regulation*.
- [https://www.bankingsupervision.europa.eu/press/publications/newsletter/2019/html/ssm.nl190213\\_5.en.html](https://www.bankingsupervision.europa.eu/press/publications/newsletter/2019/html/ssm.nl190213_5.en.html)
- Evans, E. (2004). *Domain-driven design: Tackling complexity in the heart of software* (First edition). Addison-Wesley Professional.

- Guo, X., Leung, T. L., Shek, H., & Wong, S. P.-S. (2017). *Quantitative trading: Algorithms, analytics, data, models, optimization*. CRC Press.
- Gurrib, I. (2018). Performance of the Average Directional Index as a market timing tool for the most actively traded USD based currency pairs. *Banks and Bank Systems*, 13(3), 58–70.
- James, C. (2021). Technical Indicator. *Investopedia*.  
<https://www.investopedia.com/terms/t/technicalindicator.asp>
- Johnson, B. (2010). *Algorithmic trading & DMA: an introduction to direct access trading strategies*. 4Myeloma Press.
- Kissell, R. (2006). The Expanded Implementation Shortfall: Understanding Transaction Cost Components. *The Journal of Trading*, 1(3), 6–16.
- Leshik, E., & Cralle, J. (2011). *An Introduction to Algorithmic Trading: Basic to Advanced Strategies*. John Wiley and Sons.
- Lien, K. (2015). *Day trading and swing trading the currency market: Technical and fundamental strategies to profit from market moves* (Third edition). Wiley.
- Markowitz, H. (1952, March). Portfolio Selection. *The Journal of Finance*, 7(1), 77–91.
- Mitchell, C. (2021). Average Directional Index (ADX). *Invesopedia*.  
<https://www.investopedia.com/terms/a/adx.asp>
- MQL5 Reference. (2021). *MQL5*. <https://www.mql5.com/en/docs>
- Mukerji, P., Chung, C., Walsh, T., & Xiong, B. (2019). The Impact of Algorithmic Trading in a Simulated Asset Market. *Journal of Risk and Financial Management*, 12(68), 11.
- Narang, R. K. (2009). *Inside the black box: The simple truth about quantitative trading* (1st ed.). John Wiley & Sons.
- Neely, C. J., Rapach, D. E., Tu, J., & Zhou Guofu. (2014, July). Forecasting the Equity Risk Premium: The Role of Technical Indicators. *Management Science*, 60(7), 1617–1859.
- Tobin, J. (1958, February). Liquidity Preference as Behavior Towards Risk. *The Review of Economic Studies*, 25(2), 65–86.



Treleaven, P., Galas, M., & Lalchand, V. (2013, November). Review Articles: Algorithmic Trading Review. *Communications of the ACM*, 56(11), 76–85.

Wilder Jr., J. weeles. (1978). *New Concepts in Technical trading Systems*. Trend Research.

Zhu, Y., & Zhou, G. (2009). Technical analysis: An asset allocation perspective on the use of moving averages. *Journal of Financial Economics*, 92, 519–544.

## APPENDIX A – GBP/USD BACK-TESTING EXECUTION LOG

EL	0	11:44:41.594	Tester	Cloud servers switched off
DS	0	11:45:04.746	Core 1	agent process started on 127.0.0.1:3000
ME	0	11:45:04.746	Core 1	connecting to 127.0.0.1:3000
RQ	0	11:45:05.250	Core 1	connected
JK	0	11:45:05.259	Core 1	authorized (agent build 2940)
QS	0	11:45:05.266	Tester	GBPUSD,Daily (BDSwissGlobal-Server01): testing of
Experts\masters_project\perfect_order_v6.1.ex5 from 2005.01.01 00:00 to 2020.12.31 00:00				
RL	0	11:45:05.271	Core 1	common synchronization completed
JF	3	11:45:05.288	Tester	GBPUSD: custom settings for the symbol applied from file
'MQL5\Profiles\Tester\Symbols\GBPUSD.txt'				
PG	0	11:45:08.808	Tester	quality of analyzed history is 92%
ER	0	11:45:11.528	Core 1	MetaTester 5 started on 127.0.0.1:3000
PE	0	11:45:11.528	Core 1	initialization finished
KQ	0	11:45:11.528	Core 1	login (build 2940)
FH	0	11:45:11.528	Core 1	4372 bytes of account info loaded
RO	0	11:45:11.528	Core 1	1470 bytes of tester parameters loaded
PH	0	11:45:11.528	Core 1	3772 bytes of input parameters loaded
CM	0	11:45:11.528	Core 1	481 bytes of symbols list loaded (79 symbols)
GD	0	11:45:11.528	Core 1	expert file added:
Experts\masters_project\perfect_order_v6.1.ex5. 43280 bytes loaded				
OM	0	11:45:11.528	Core 1	19973 Mb available, 249 blocks set for ticks generating
MO	0	11:45:11.528	Core 1	calculate profit in pips, initial deposit 100000, leverage 1:100
KK	0	11:45:11.528	Core 1	successfully initialized
ML	0	11:45:11.528	Core 1	44 Kb of total initialization data received
KG	0	11:45:11.528	Core 1	Intel Core i5-4590 @ 3.30GHz, 32695 MB
QL	0	11:45:11.528	Core 1	GBPUSD: symbol to be synchronized
JG	0	11:45:11.528	Core 1	GBPUSD: symbol synchronized, 3720 bytes of symbol info received
GS	0	11:45:11.528	Core 1	GBPUSD: load 27 bytes of history data to synchronize in
0:00:00.003				
GM	0	11:45:11.528	Core 1	GBPUSD: history synchronized from 2004.01.01 to 2020.12.31
IF	0	11:45:11.528	Core 1	GBPUSD,Daily: history cache allocated for 4436 bars and contains
262 bars from 2004.01.01 00:00 to 2004.12.31 00:00				
HF	0	11:45:11.528	Core 1	GBPUSD,Daily: history begins from 2004.01.01 00:00
LF	0	11:45:11.528	Core 1	GBPUSD,Daily (BDSwissGlobal-Server01): every tick generating
HR	0	11:45:11.528	Core 1	GBPUSD,Daily: testing of
Experts\masters_project\perfect_order_v6.1.ex5 from 2005.01.01 00:00 to 2020.12.31 00:00 started with				
inputs:				
KL	0	11:45:11.528	Core 1	riskSize=0.02
EF	0	11:45:11.528	Core 1	fastMA1=10
OR	0	11:45:11.528	Core 1	fastMA2=20
NP	0	11:45:11.528	Core 1	midMA=50
FK	0	11:45:11.528	Core 1	slowMA1=100
FP	0	11:45:11.528	Core 1	slowMA2=200
HP	0	11:45:11.528	Core 1	adxPeriod=14
ND	0	11:45:23.736	Core 1	2005.03.09 00:01:00 buySignal
GR	0	11:45:23.736	Core 1	2005.03.09 00:01:00 buy_order_approved
EF	0	11:45:23.736	Core 1	2005.03.09 00:01:00 market buy 0.9 GBPUSD sl: 1.90780 (1.92970
/ 1.93010 / 1.92970)				
PF	0	11:45:23.736	Core 1	2005.03.09 00:01:00 deal #2 buy 0.9 GBPUSD at 1.93010 done
(based on order #2)				
RL	0	11:45:23.736	Core 1	2005.03.09 00:01:00 deal performed [#2 buy 0.9 GBPUSD at
1.93010]				
LQ	0	11:45:23.736	Core 1	2005.03.09 00:01:00 order performed buy 0.9 at 1.93010 [#2 buy
0.9 GBPUSD at 1.93010]				
JG	0	11:45:23.736	Core 1	2005.03.09 00:01:00 CTrade::OrderSend: market buy 0.90 GBPUSD
sl: 1.90780 [done at 1.93010]				
NH	0	11:45:23.736	Core 1	2005.03.09 00:01:00 Execution result: done at 1.93010
CD	0	11:45:23.736	Core 1	2005.03.09 00:01:00 Execution Module initialization complete.
JM	0	11:45:23.736	Core 1	2005.03.21 09:27:28 stop-loss triggered #2 buy 0.9 GBPUSD
1.93010 sl: 1.90780 [#3 sell 0.9 GBPUSD at 1.90780]				
KL	0	11:45:23.736	Core 1	2005.03.21 09:27:28 deal #3 sell 0.9 GBPUSD at 1.90747 done
(based on order #3)				
LL	0	11:45:23.736	Core 1	2005.03.21 09:27:28 deal performed [#3 sell 0.9 GBPUSD at
1.90747]				
CF	0	11:45:23.736	Core 1	2005.03.21 09:27:28 order performed sell 0.9 at 1.90747 [#3
sell 0.9 GBPUSD at 1.90780]				
JD	0	11:45:23.736	Core 1	2005.07.12 00:01:00 sellSignal
IP	0	11:45:23.736	Core 1	2005.07.12 00:01:00 sell_order_approved
LE	0	11:45:23.736	Core 1	2005.07.12 00:01:00 market sell 4.26 GBPUSD sl: 1.76230
(1.75770 / 1.75810 / 1.75770)				
PI	0	11:45:23.736	Core 1	2005.07.12 00:01:00 deal #4 sell 4.26 GBPUSD at 1.75770 done
(based on order #4)				
LE	0	11:45:23.736	Core 1	2005.07.12 00:01:00 deal performed [#4 sell 4.26 GBPUSD at
1.75770]				
NL	0	11:45:23.736	Core 1	2005.07.12 00:01:00 order performed sell 4.26 at 1.75770 [#4
sell 4.26 GBPUSD at 1.75770]				
HL	0	11:45:23.736	Core 1	2005.07.12 00:01:00 CTrade::OrderSend: market sell 4.26 GBPUSD
sl: 1.76230 [done at 1.75770]				
KL	0	11:45:23.736	Core 1	2005.07.12 00:01:00 Execution result: done at 1.75770
EI	0	11:45:23.736	Core 1	2005.07.12 00:01:00 Execution Module initialization complete.
QI	0	11:45:23.736	Core 1	2005.07.12 04:03:32 stop-loss triggered #4 sell 4.26 GBPUSD
1.75770 sl: 1.76230 [#5 buy 4.26 GBPUSD at 1.76230]				
KD	0	11:45:23.736	Core 1	2005.07.12 04:03:32 deal #5 buy 4.26 GBPUSD at 1.76230 done

```

(based on order #5)
RM 0 11:45:23.736 Core 1 2005.07.12 04:03:32 deal performed [#5 buy 4.26 GBPUSD at
1.76230]
DS 0 11:45:23.736 Core 1 2005.07.12 04:03:32 order performed buy 4.26 at 1.76230 [#5 buy
4.26 GBPUSD at 1.76230]
EP 0 11:45:23.736 Core 1 2005.11.18 00:01:00 sellSignal
FE 0 11:45:23.736 Core 1 2005.11.18 00:01:00 sell_order_approved
LQ 0 11:45:23.736 Core 1 2005.11.18 00:01:00 market sell 0.76 GBPUSD sl: 1.74380
(1.71850 / 1.71890 / 1.71850)
CE 0 11:45:23.736 Core 1 2005.11.18 00:01:00 deal #6 sell 0.76 GBPUSD at 1.71850 done
(based on order #6)
IH 0 11:45:23.736 Core 1 2005.11.18 00:01:00 deal performed [#6 sell 0.76 GBPUSD at
1.71850]
OI 0 11:45:23.736 Core 1 2005.11.18 00:01:00 order performed sell 0.76 at 1.71850 [#6
sell 0.76 GBPUSD at 1.71850]
CG 0 11:45:23.736 Core 1 2005.11.18 00:01:00 CTrade::OrderSend: market sell 0.76 GBPUSD
sl: 1.74380 [done at 1.71850]
GQ 0 11:45:23.736 Core 1 2005.11.18 00:01:00 Execution result: done at 1.71850
JM 0 11:45:23.736 Core 1 2005.11.18 00:01:00 Execution Module initialization complete.
HE 0 11:45:23.736 Core 1 2005.12.05 18:47:40 stop-loss triggered #6 sell 0.76 GBPUSD
1.71850 sl: 1.74380 [#7 buy 0.76 GBPUSD at 1.74380]
NK 0 11:45:23.736 Core 1 2005.12.05 18:47:40 deal #7 buy 0.76 GBPUSD at 1.74388 done
(based on order #7)
QI 0 11:45:23.736 Core 1 2005.12.05 18:47:40 deal performed [#7 buy 0.76 GBPUSD at
1.74388]
LO 0 11:45:23.736 Core 1 2005.12.05 18:47:40 order performed buy 0.76 at 1.74388 [#7 buy
0.76 GBPUSD at 1.74380]
MP 0 11:45:23.736 Core 1 2006.05.25 00:01:00 buySignal
DD 0 11:45:23.736 Core 1 2006.05.25 00:01:00 Type: Buy | EP: 1.8691 | SL: 1.8791 | Diff:
-0.010000000000000001
KH 0 11:45:23.736 Core 1 2006.05.25 00:01:00 tradeRejected: SL incompatible with trade
JP 0 11:45:23.736 Core 1 2006.08.09 00:01:00 buySignal
CE 0 11:45:23.736 Core 1 2006.08.09 00:01:00 buy_order_approved
PQ 0 11:45:23.736 Core 1 2006.08.09 00:01:00 market buy 0.56 GBPUSD sl: 1.87310 (1.90630
/ 1.90660 / 1.90630)
JQ 0 11:45:23.736 Core 1 2006.08.09 00:01:00 deal #8 buy 0.56 GBPUSD at 1.90660 done
(based on order #8)
PP 0 11:45:23.736 Core 1 2006.08.09 00:01:00 deal performed [#8 buy 0.56 GBPUSD at
1.90660]
DE 0 11:45:23.736 Core 1 2006.08.09 00:01:00 order performed buy 0.56 at 1.90660 [#8 buy
0.56 GBPUSD at 1.90660]
ED 0 11:45:23.736 Core 1 2006.08.09 00:01:00 CTrade::OrderSend: market buy 0.56 GBPUSD
sl: 1.87310 [done at 1.90660]
RE 0 11:45:23.736 Core 1 2006.08.09 00:01:00 Execution result: done at 1.90660
QQ 0 11:45:23.736 Core 1 2006.08.09 00:01:00 Execution Module initialization complete.
DL 0 11:45:23.736 Core 1 2006.08.28 00:01:00 market sell 0.56 GBPUSD, close #8 (1.88740
/ 1.88770 / 1.88740)
CD 0 11:45:23.736 Core 1 2006.08.28 00:01:00 deal #9 sell 0.56 GBPUSD at 1.88740 done
(based on order #9)
HI 0 11:45:23.736 Core 1 2006.08.28 00:01:00 deal performed [#9 sell 0.56 GBPUSD at
1.88740]
HH 0 11:45:23.736 Core 1 2006.08.28 00:01:00 order performed sell 0.56 at 1.88740 [#9
sell 0.56 GBPUSD at 1.88740]
GP 0 11:45:23.736 Core 1 2006.08.28 00:01:00 CTrade::OrderSend: market sell 0.56
position #8 GBPUSD [done at 1.88740]
IP 0 11:45:23.736 Core 1 2006.08.28 00:01:00 Execution result: done at 1.88740
DN 0 11:45:23.736 Core 1 2006.09.08 00:01:00 buySignal
QN 0 11:45:23.736 Core 1 2006.09.08 00:01:00 Type: Buy | EP: 1.8764 | SL: 1.8956 | Diff:
-0.019200000000000001
FM 0 11:45:23.736 Core 1 2006.09.08 00:01:00 tradeRejected: SL incompatible with trade
NO 0 11:45:23.736 Core 1 2006.11.15 00:00:00 buySignal
IJ 0 11:45:23.736 Core 1 2006.11.15 00:00:00 Type: Buy | EP: 1.8958 | SL: 1.9005 | Diff:
-0.004700000000000001
NM 0 11:45:23.736 Core 1 2006.11.15 00:00:00 tradeRejected: SL incompatible with trade
OL 0 11:45:23.736 Core 1 2006.12.04 00:00:00 buySignal
FJ 0 11:45:23.736 Core 1 2006.12.04 00:00:00 buy_order_approved
RN 0 11:45:23.736 Core 1 2006.12.04 00:00:00 market buy 0.35 GBPUSD sl: 1.93050 (1.98320
/ 1.98350 / 1.98320)
RJ 0 11:45:23.736 Core 1 2006.12.04 00:00:00 deal #10 buy 0.35 GBPUSD at 1.98350 done
(based on order #10)
CD 0 11:45:23.736 Core 1 2006.12.04 00:00:00 deal performed [#10 buy 0.35 GBPUSD at
1.98350]
LJ 0 11:45:23.736 Core 1 2006.12.04 00:00:00 order performed buy 0.35 at 1.98350 [#10
buy 0.35 GBPUSD at 1.98350]
KH 0 11:45:23.736 Core 1 2006.12.04 00:00:00 CTrade::OrderSend: market buy 0.35 GBPUSD
sl: 1.93050 [done at 1.98350]
EQ 0 11:45:23.736 Core 1 2006.12.04 00:00:00 Execution result: done at 1.98350
HM 0 11:45:23.736 Core 1 2006.12.04 00:00:00 Execution Module initialization complete.
QK 0 11:45:23.736 Core 1 2006.12.26 00:27:00 market sell 0.35 GBPUSD, close #10 (1.95790
/ 1.95820 / 1.95790)
JH 0 11:45:23.736 Core 1 2006.12.26 00:27:00 deal #11 sell 0.35 GBPUSD at 1.95790 done
(based on order #11)
NF 0 11:45:23.736 Core 1 2006.12.26 00:27:00 deal performed [#11 sell 0.35 GBPUSD at
1.95790]
LO 0 11:45:23.736 Core 1 2006.12.26 00:27:00 order performed sell 0.35 at 1.95790 [#11
sell 0.35 GBPUSD at 1.95790]
IO 0 11:45:23.736 Core 1 2006.12.26 00:27:00 CTrade::OrderSend: market sell 0.35
position #10 GBPUSD [done at 1.95790]

```

QL	0	11:45:23.736	Core 1	2006.12.26 00:27:00	Execution result: done at 1.95790
PK	0	11:45:23.736	Core 1	2007.01.26 00:00:00	buySignal
QN	0	11:45:23.736	Core 1	2007.01.26 00:00:00	Type: Buy   EP: 1.9634   SL: 1.9694   Diff:
-0.006000000000000005					
PQ	0	11:45:23.736	Core 1	2007.01.26 00:00:00	tradeRejected: SL incompatible with trade
FK	0	11:45:23.736	Core 1	2007.04.30 00:00:00	buySignal
EO	0	11:45:23.736	Core 1	2007.04.30 00:00:00	Type: Buy   EP: 1.9967   SL: 1.997   Diff:
-0.0002999999999997449					
FP	0	11:45:23.736	Core 1	2007.04.30 00:00:00	tradeRejected: SL incompatible with trade
DH	0	11:45:23.736	Core 1	2007.07.06 00:00:00	buySignal
QN	0	11:45:23.736	Core 1	2007.07.06 00:00:00	buy_order_approved
DI	0	11:45:23.736	Core 1	2007.07.06 00:00:00	market buy 1.71 GBPUSD sl: 2.00090 (2.01150
/ 2.01170 / 2.01150)					
CI	0	11:45:23.736	Core 1	2007.07.06 00:00:00	deal #12 buy 1.71 GBPUSD at 2.01170 done
(based on order #12)					
PK	0	11:45:23.736	Core 1	2007.07.06 00:00:00	deal performed [#12 buy 1.71 GBPUSD at
2.01170]					
IM	0	11:45:23.736	Core 1	2007.07.06 00:00:00	order performed buy 1.71 at 2.01170 [#12
buy 1.71 GBPUSD at 2.01170]					
IL	0	11:45:23.736	Core 1	2007.07.06 00:00:00	CTrade::OrderSend: market buy 1.71 GBPUSD
sl: 2.00090 [done at 2.01170]					
KM	0	11:45:23.736	Core 1	2007.07.06 00:00:00	Execution result: done at 2.01170
GJ	0	11:45:23.736	Core 1	2007.07.06 00:00:00	Execution Module initialization complete.
KF	0	11:45:23.736	Core 1	2007.08.07 00:00:30	market sell 1.71 GBPUSD, close #12 (2.03110
/ 2.03130 / 2.03110)					
DM	0	11:45:23.736	Core 1	2007.08.07 00:00:30	deal #13 sell 1.71 GBPUSD at 2.03110 done
(based on order #13)					
NS	0	11:45:23.736	Core 1	2007.08.07 00:00:30	deal performed [#13 sell 1.71 GBPUSD at
2.03110]					
QR	0	11:45:23.736	Core 1	2007.08.07 00:00:30	order performed sell 1.71 at 2.03110 [#13
sell 1.71 GBPUSD at 2.03110]					
IL	0	11:45:23.736	Core 1	2007.08.07 00:00:30	CTrade::OrderSend: market sell 1.71
position #12 GBPUSD [done at 2.03110]					
HI	0	11:45:23.736	Core 1	2007.08.07 00:00:30	Execution result: done at 2.03110
DH	0	11:45:23.736	Core 1	2008.08.19 00:00:00	sellSignal
GM	0	11:45:23.736	Core 1	2008.08.19 00:00:00	sell_order_approved
GI	0	11:45:23.736	Core 1	2008.08.19 00:00:00	market sell 0.38 GBPUSD sl: 1.91220
(1.86160 / 1.86180 / 1.86160)					
RM	0	11:45:23.736	Core 1	2008.08.19 00:00:00	deal #14 sell 0.38 GBPUSD at 1.86160 done
(based on order #14)					
ES	0	11:45:23.736	Core 1	2008.08.19 00:00:00	deal performed [#14 sell 0.38 GBPUSD at
1.86160]					
ER	0	11:45:23.736	Core 1	2008.08.19 00:00:00	order performed sell 0.38 at 1.86160 [#14
sell 0.38 GBPUSD at 1.86160]					
FO	0	11:45:23.736	Core 1	2008.08.19 00:00:00	CTrade::OrderSend: market sell 0.38 GBPUSD
sl: 1.91220 [done at 1.86160]					
LI	0	11:45:23.736	Core 1	2008.08.19 00:00:00	Execution result: done at 1.86160
KF	0	11:45:23.736	Core 1	2008.08.19 00:00:00	Execution Module initialization complete.
OM	0	11:45:23.736	Core 1	2008.09.24 00:00:00	market buy 0.38 GBPUSD, close #14 (1.85320
/ 1.85340 / 1.85320)					
FN	0	11:45:23.736	Core 1	2008.09.24 00:00:00	deal #15 buy 0.38 GBPUSD at 1.85340 done
(based on order #15)					
LP	0	11:45:23.736	Core 1	2008.09.24 00:00:00	deal performed [#15 buy 0.38 GBPUSD at
1.85340]					
CF	0	11:45:23.736	Core 1	2008.09.24 00:00:00	order performed buy 0.38 at 1.85340 [#15
buy 0.38 GBPUSD at 1.85340]					
MH	0	11:45:23.736	Core 1	2008.09.24 00:00:00	CTrade::OrderSend: market buy 0.38 position
#14 GBPUSD [done at 1.85340]					
HD	0	11:45:23.736	Core 1	2008.09.24 00:00:00	Execution result: done at 1.85340
KL	0	11:45:23.736	Core 1	2008.10.14 00:00:30	sellSignal
LH	0	11:45:23.736	Core 1	2008.10.14 00:00:30	sell_order_approved
DM	0	11:45:23.736	Core 1	2008.10.14 00:00:30	market sell 0.77 GBPUSD sl: 1.76580
(1.74100 / 1.74120 / 1.74100)					
EQ	0	11:45:23.736	Core 1	2008.10.14 00:00:30	deal #16 sell 0.77 GBPUSD at 1.74100 done
(based on order #16)					
LO	0	11:45:23.736	Core 1	2008.10.14 00:00:30	deal performed [#16 sell 0.77 GBPUSD at
1.74100]					
PF	0	11:45:23.736	Core 1	2008.10.14 00:00:30	order performed sell 0.77 at 1.74100 [#16
sell 0.77 GBPUSD at 1.74100]					
QK	0	11:45:23.736	Core 1	2008.10.14 00:00:30	CTrade::OrderSend: market sell 0.77 GBPUSD
sl: 1.76580 [done at 1.74100]					
RE	0	11:45:23.736	Core 1	2008.10.14 00:00:30	Execution result: done at 1.74100
HQ	0	11:45:23.736	Core 1	2008.10.14 00:00:30	Execution Module initialization complete.
DP	0	11:45:23.736	Core 1	2008.12.05 00:03:00	market buy 0.77 GBPUSD, close #16 (1.46820
/ 1.46840 / 1.46820)					
OK	0	11:45:23.736	Core 1	2008.12.05 00:03:00	deal #17 buy 0.77 GBPUSD at 1.46840 done
(based on order #17)					
GE	0	11:45:23.736	Core 1	2008.12.05 00:03:00	deal performed [#17 buy 0.77 GBPUSD at
1.46840]					
EK	0	11:45:23.736	Core 1	2008.12.05 00:03:00	order performed buy 0.77 at 1.46840 [#17
buy 0.77 GBPUSD at 1.46840]					
FL	0	11:45:23.736	Core 1	2008.12.05 00:03:00	CTrade::OrderSend: market buy 0.77 position
#16 GBPUSD [done at 1.46840]					
DP	0	11:45:23.736	Core 1	2008.12.05 00:03:00	Execution result: done at 1.46840
DQ	0	11:45:23.736	Core 1	2008.12.17 00:01:00	sellSignal
NQ	0	11:45:23.736	Core 1	2008.12.17 00:01:00	Type: Sell   EP: 1.5577   SL: 1.4878
Diff: -0.06990000000000007					
NM	0	11:45:23.736	Core 1	2008.12.17 00:01:00	tradeRejected: SL incompatible with trade

QP	0	11:45:23.736	Core 1	2009.01.07 00:01:30	sellSignal
NF	0	11:45:23.736	Core 1	2009.01.07 00:01:30	Type: Sell   EP: 1.4905   SL: 1.4551
Diff: -0.03539999999999998					
KL	0	11:45:23.736	Core 1	2009.01.07 00:01:30	tradeRejected: SL incompatible with trade
FS	0	11:45:23.736	Core 1	2009.01.28 00:00:00	sellSignal
GG	0	11:45:23.736	Core 1	2009.01.28 00:00:00	Type: Sell   EP: 1.4152   SL: 1.4025
Diff: -0.012699999999999993					
LL	0	11:45:23.736	Core 1	2009.01.28 00:00:00	tradeRejected: SL incompatible with trade
KR	0	11:45:29.839	Core 1	2010.02.17 00:00:00	sellSignal
MG	0	11:45:29.839	Core 1	2010.02.17 00:00:00	Type: Sell   EP: 1.57839   SL: 1.57631
Diff: -0.0020800000000000082					
KJ	0	11:45:29.839	Core 1	2010.02.17 00:00:00	tradeRejected: SL incompatible with trade
LM	0	11:45:29.839	Core 1	2010.04.05 00:00:00	sellSignal
KE	0	11:45:29.839	Core 1	2010.04.05 00:00:00	Type: Sell   EP: 1.52658   SL: 1.50178
Diff: -0.024799999999999993					
NI	0	11:45:29.839	Core 1	2010.04.05 00:00:00	tradeRejected: SL incompatible with trade
EL	0	11:45:29.839	Core 1	2010.05.20 00:00:30	sellSignal
RH	0	11:45:29.839	Core 1	2010.05.20 00:00:30	sell_order_approved
IN	0	11:45:29.839	Core 1	2010.05.20 00:00:30	market sell 0.5 GBPUSD sl: 1.49160 (1.44500 / 1.44525 / 1.44500)
OR	0	11:45:29.839	Core 1	2010.05.20 00:00:30	deal #18 sell 0.5 GBPUSD at 1.44500 done
(based on order #18)					
FL	0	11:45:29.839	Core 1	2010.05.20 00:00:30	deal performed [#18 sell 0.5 GBPUSD at 1.44500]
FF	0	11:45:29.839	Core 1	2010.05.20 00:00:30	order performed sell 0.5 at 1.44500 [#18 sell 0.5 GBPUSD at 1.44500]
ID	0	11:45:29.839	Core 1	2010.05.20 00:00:30	CTrade::OrderSend: market sell 0.50 GBPUSD
sl: 1.49160 [done at 1.44500]					
OE	0	11:45:29.839	Core 1	2010.05.20 00:00:30	Execution result: done at 1.44500
LQ	0	11:45:29.839	Core 1	2010.05.20 00:00:30	Execution Module initialization complete.
LS	0	11:45:29.839	Core 1	2010.06.09 00:00:00	market buy 0.5 GBPUSD, close #18 (1.44522 / 1.44550 / 1.44522)
GH	0	11:45:29.839	Core 1	2010.06.09 00:00:00	deal #19 buy 0.5 GBPUSD at 1.44550 done
(based on order #19)					
CF	0	11:45:29.839	Core 1	2010.06.09 00:00:00	deal performed [#19 buy 0.5 GBPUSD at 1.44550]
FL	0	11:45:29.839	Core 1	2010.06.09 00:00:00	order performed buy 0.5 at 1.44550 [#19 buy 0.5 GBPUSD at 1.44550]
LM	0	11:45:29.839	Core 1	2010.06.09 00:00:00	CTrade::OrderSend: market buy 0.50 position
#18 GBPUSD [done at 1.44550]					
GS	0	11:45:29.839	Core 1	2010.06.09 00:00:00	Execution result: done at 1.44550
QI	0	11:45:29.839	Core 1	2010.10.21 00:00:00	buySignal
KL	0	11:45:29.839	Core 1	2010.10.21 00:00:00	Type: Buy   EP: 1.58395   SL: 1.58875
Diff: -0.00480000000000000137					
MN	0	11:45:29.839	Core 1	2010.10.21 00:00:00	tradeRejected: SL incompatible with trade
PN	0	11:45:29.839	Core 1	2010.11.10 00:00:00	buySignal
HM	0	11:45:29.839	Core 1	2010.11.10 00:00:00	Type: Buy   EP: 1.59809   SL: 1.60059
Diff: -0.0024999999999999947					
LM	0	11:45:29.839	Core 1	2010.11.10 00:00:00	tradeRejected: SL incompatible with trade
CO	0	11:45:29.839	Core 1	2011.04.18 00:00:00	buySignal
RK	0	11:45:29.839	Core 1	2011.04.18 00:00:00	buy_order_approved
EM	0	11:45:29.839	Core 1	2011.04.18 00:00:00	market buy 19.78 GBPUSD sl: 1.63130 (1.63188 / 1.63248 / 1.63188)
CI	0	11:45:29.839	Core 1	2011.04.18 00:00:00	deal #20 buy 19.78 GBPUSD at 1.63248 done
(based on order #20)					
IG	0	11:45:29.839	Core 1	2011.04.18 00:00:00	deal performed [#20 buy 19.78 GBPUSD at 1.63248]
OJ	0	11:45:29.839	Core 1	2011.04.18 00:00:00	order performed buy 19.78 at 1.63248 [#20 buy 19.78 GBPUSD at 1.63248]
RK	0	11:45:29.839	Core 1	2011.04.18 00:00:00	CTrade::OrderSend: market buy 19.78 GBPUSD
sl: 1.63130 [done at 1.63248]					
EQ	0	11:45:29.839	Core 1	2011.04.18 00:00:00	Execution result: done at 1.63248
LM	0	11:45:29.839	Core 1	2011.04.18 00:00:00	Execution Module initialization complete.
DD	0	11:45:29.839	Core 1	2011.04.18 00:14:16	stop-loss triggered #20 buy 19.78 GBPUSD
1.63248 sl: 1.63130 [#21 sell 19.78 GBPUSD at 1.63130]					
KF	0	11:45:29.839	Core 1	2011.04.18 00:14:16	deal #21 sell 19.78 GBPUSD at 1.63127 done
(based on order #21)					
DH	0	11:45:29.839	Core 1	2011.04.18 00:14:16	deal performed [#21 sell 19.78 GBPUSD at 1.63127]
HJ	0	11:45:29.839	Core 1	2011.04.18 00:14:16	order performed sell 19.78 at 1.63127 [#21 sell 19.78 GBPUSD at 1.63130]
NI	0	11:45:35.942	Core 1	2011.10.12 00:00:00	sellSignal
PI	0	11:45:35.942	Core 1	2011.10.12 00:00:00	Type: Sell   EP: 1.55901   SL: 1.54911
Diff: -0.0099000000000000002					
LE	0	11:45:35.942	Core 1	2011.10.12 00:00:00	tradeRejected: SL incompatible with trade
PH	0	11:45:35.942	Core 1	2011.12.09 00:00:00	sellSignal
CL	0	11:45:35.942	Core 1	2011.12.09 00:00:00	sell_order_approved
DI	0	11:45:35.942	Core 1	2011.12.09 00:00:00	market sell 2.25 GBPUSD sl: 1.57242 (1.56227 / 1.56261 / 1.56227)
CM	0	11:45:35.942	Core 1	2011.12.09 00:00:00	deal #22 sell 2.25 GBPUSD at 1.56227 done
(based on order #22)					
KS	0	11:45:35.942	Core 1	2011.12.09 00:00:00	deal performed [#22 sell 2.25 GBPUSD at 1.56227]
NR	0	11:45:35.942	Core 1	2011.12.09 00:00:00	order performed sell 2.25 at 1.56227 [#22 sell 2.25 GBPUSD at 1.56227]
EO	0	11:45:35.942	Core 1	2011.12.09 00:00:00	CTrade::OrderSend: market sell 2.25 GBPUSD
sl: 1.57242 [done at 1.56227]					
KI	0	11:45:35.942	Core 1	2011.12.09 00:00:00	Execution result: done at 1.56227

OE	0	11:45:35.942	Core 1	2011.12.09 00:00:00	Execution Module initialization complete.
KL	0	11:45:35.942	Core 1	2011.12.09 12:16:05	stop-loss triggered #22 sell 2.25 GBPUSD
1.56227 sl: 1.57242 [#23 buy 2.25 GBPUSD at 1.57242]					
QS	0	11:45:35.942	Core 1	2011.12.09 12:16:05	deal #23 buy 2.25 GBPUSD at 1.57243 done
(based on order #23)					
DM	0	11:45:35.942	Core 1	2011.12.09 12:16:05	deal performed [#23 buy 2.25 GBPUSD at 1.57243]
MS	0	11:45:35.942	Core 1	2011.12.09 12:16:05	order performed buy 2.25 at 1.57243 [#23 buy 2.25 GBPUSD at 1.57242]
GF	0	11:45:35.942	Core 1	2011.12.26 08:00:00	sellSignal
RS	0	11:45:35.942	Core 1	2011.12.26 08:00:00	Type: Sell   EP: 1.56266   SL: 1.55448
Diff: -0.008180000000000298					
GN	0	11:45:35.942	Core 1	2011.12.26 08:00:00	tradeRejected: SL incompatible with trade
CN	0	11:45:42.046	Core 1	2012.12.20 00:00:00	buySignal
RL	0	11:45:42.046	Core 1	2012.12.20 00:00:00	buy_order_approved
CO	0	11:45:42.046	Core 1	2012.12.20 00:00:00	market buy 1.34 GBPUSD sl: 1.60845 (1.62496 / 1.62514 / 1.62496)
CK	0	11:45:42.046	Core 1	2012.12.20 00:00:00	deal #24 buy 1.34 GBPUSD at 1.62514 done
(based on order #24)					
KE	0	11:45:42.046	Core 1	2012.12.20 00:00:00	deal performed [#24 buy 1.34 GBPUSD at 1.62514]
EK	0	11:45:42.046	Core 1	2012.12.20 00:00:00	order performed buy 1.34 at 1.62514 [#24 buy 1.34 GBPUSD at 1.62514]
JN	0	11:45:42.046	Core 1	2012.12.20 00:00:00	CTrade::OrderSend: market buy 1.34 GBPUSD
sl: 1.60845 [done at 1.62514]					
PS	0	11:45:42.046	Core 1	2012.12.20 00:00:00	Execution result: done at 1.62514
LK	0	11:45:42.046	Core 1	2012.12.20 00:00:00	Execution Module initialization complete.
HJ	0	11:45:42.046	Core 1	2012.12.27 18:01:35	stop-loss triggered #24 buy 1.34 GBPUSD
1.62514 sl: 1.60845 [#25 sell 1.34 GBPUSD at 1.60845]					
JF	0	11:45:42.046	Core 1	2012.12.27 18:01:35	deal #25 sell 1.34 GBPUSD at 1.60842 done
(based on order #25)					
KD	0	11:45:42.046	Core 1	2012.12.27 18:01:35	deal performed [#25 sell 1.34 GBPUSD at 1.60842]
FM	0	11:45:42.046	Core 1	2012.12.27 18:01:35	order performed sell 1.34 at 1.60842 [#25 sell 1.34 GBPUSD at 1.60845]
RL	0	11:45:42.046	Core 1	2013.03.22 00:00:00	sellSignal
MI	0	11:45:42.046	Core 1	2013.03.22 00:00:00	sell_order_approved
NN	0	11:45:42.046	Core 1	2013.03.22 00:00:00	market sell 45.74 GBPUSD sl: 1.51762 (1.51714 / 1.51730 / 1.51714)
LM	0	11:45:42.046	Core 1	2013.03.22 00:00:00	deal #26 sell 45.74 GBPUSD at 1.51714 done
(based on order #26)					
JO	0	11:45:42.046	Core 1	2013.03.22 00:00:00	deal performed [#26 sell 45.74 GBPUSD at 1.51714]
JE	0	11:45:42.046	Core 1	2013.03.22 00:00:00	order performed sell 45.74 at 1.51714 [#26 sell 45.74 GBPUSD at 1.51714]
QI	0	11:45:42.046	Core 1	2013.03.22 00:00:00	CTrade::OrderSend: market sell 45.74 GBPUSD
sl: 1.51762 [done at 1.51714]					
OJ	0	11:45:42.046	Core 1	2013.03.22 00:00:00	Execution result: done at 1.51714
MR	0	11:45:42.046	Core 1	2013.03.22 00:00:00	Execution Module initialization complete.
NS	0	11:45:42.046	Core 1	2013.03.22 00:03:27	stop-loss triggered #26 sell 45.74 GBPUSD
1.51714 sl: 1.51762 [#27 buy 45.74 GBPUSD at 1.51762]					
ER	0	11:45:42.046	Core 1	2013.03.22 00:03:27	deal #27 buy 45.74 GBPUSD at 1.51764 done
(based on order #27)					
RP	0	11:45:42.046	Core 1	2013.03.22 00:03:27	deal performed [#27 buy 45.74 GBPUSD at 1.51764]
CE	0	11:45:42.046	Core 1	2013.03.22 00:03:27	order performed buy 45.74 at 1.51764 [#27 buy 45.74 GBPUSD at 1.51762]
FD	0	11:45:42.046	Core 1	2013.06.05 00:00:00	sellSignal
CQ	0	11:45:42.046	Core 1	2013.06.05 00:00:00	Type: Sell   EP: 1.5315   SL: 1.51455
Diff: -0.016950000000000002					
RQ	0	11:45:42.046	Core 1	2013.06.05 00:00:00	tradeRejected: SL incompatible with trade
KH	0	11:45:42.046	Core 1	2013.10.10 00:00:00	buySignal
FO	0	11:45:42.046	Core 1	2013.10.10 00:00:00	Type: Buy   EP: 1.59529   SL: 1.6154
Diff: -0.020110000000000007					
KP	0	11:45:42.046	Core 1	2013.10.10 00:00:00	tradeRejected: SL incompatible with trade
HH	0	11:45:42.046	Core 1	2013.11.01 00:00:00	buySignal
ML	0	11:45:42.046	Core 1	2013.11.01 00:00:00	Type: Buy   EP: 1.60434   SL: 1.61502
Diff: -0.010679999999999998					
HO	0	11:45:42.046	Core 1	2013.11.01 00:00:00	tradeRejected: SL incompatible with trade
II	0	11:45:42.046	Core 1	2013.12.05 00:00:00	buySignal
LM	0	11:45:42.046	Core 1	2013.12.05 00:00:00	buy_order_approved
EK	0	11:45:42.046	Core 1	2013.12.05 00:00:00	market buy 2.1 GBPUSD sl: 1.62766 (1.63784 / 1.63792 / 1.63784)
KK	0	11:45:42.046	Core 1	2013.12.05 00:00:00	deal #28 buy 2.1 GBPUSD at 1.63792 done
(based on order #28)					
IH	0	11:45:42.046	Core 1	2013.12.05 00:00:00	deal performed [#28 buy 2.1 GBPUSD at 1.63792]
EM	0	11:45:42.046	Core 1	2013.12.05 00:00:00	order performed buy 2.1 at 1.63792 [#28 buy 2.1 GBPUSD at 1.63792]
RM	0	11:45:42.046	Core 1	2013.12.05 00:00:00	CTrade::OrderSend: market buy 2.10 GBPUSD
sl: 1.62766 [done at 1.63792]					
OR	0	11:45:42.046	Core 1	2013.12.05 00:00:00	Execution result: done at 1.63792
HJ	0	11:45:42.046	Core 1	2013.12.05 00:00:00	Execution Module initialization complete.
GH	0	11:45:42.046	Core 1	2013.12.13 12:38:35	stop-loss triggered #28 buy 2.1 GBPUSD
1.63792 sl: 1.62766 [#29 sell 2.1 GBPUSD at 1.62766]					
EJ	0	11:45:42.046	Core 1	2013.12.13 12:38:35	deal #29 sell 2.1 GBPUSD at 1.62765 done
(based on order #29)					
RE	0	11:45:42.046	Core 1	2013.12.13 12:38:35	deal performed [#29 sell 2.1 GBPUSD at 1.62765]

1.62765]					
RO	0	11:45:42.046	Core 1	2013.12.13 12:38:35	order performed sell 2.1 at 1.62765 [#29
sell 2.1 GBPUSD at 1.62766]					
QM	0	11:45:42.046	Core 1	2014.01.06 00:00:00	buySignal
OH	0	11:45:42.046	Core 1	2014.01.06 00:00:00	Type: Buy   EP: 1.64128   SL: 1.64597
Diff: -0.0046900000000000083					
EJ	0	11:45:42.046	Core 1	2014.01.06 00:00:00	tradeRejected: SL incompatible with trade
KR	0	11:45:42.046	Core 1	2014.02.03 00:00:00	buySignal
QI	0	11:45:42.046	Core 1	2014.02.03 00:00:00	Type: Buy   EP: 1.64305   SL: 1.64743
Diff: -0.0043799999999999828					
GI	0	11:45:42.046	Core 1	2014.02.03 00:00:00	tradeRejected: SL incompatible with trade
OS	0	11:45:42.046	Core 1	2014.02.25 00:00:00	buySignal
NG	0	11:45:42.046	Core 1	2014.02.25 00:00:00	buy_order_approved
OM	2	11:45:42.046	Core 1	2014.02.25 00:00:00	failed market buy 351.11 GBPUSD sl: 1.66556
[Invalid volume]					
ML	0	11:45:42.046	Core 1	2014.02.25 00:00:00	CTrade::OrderSend: market buy 351.11 GBPUSD
sl: 1.66556 [invalid volume]					
QQ	0	11:45:42.046	Core 1	2014.02.25 00:00:00	Execution result: invalid volume
NG	0	11:45:42.046	Core 1	2014.02.25 00:00:00	Execution Module initialization complete.
LQ	0	11:45:42.046	Core 1	2014.04.11 00:00:00	buySignal
IE	0	11:45:42.046	Core 1	2014.04.11 00:00:00	buy_order_approved
MQ	0	11:45:42.046	Core 1	2014.04.11 00:00:00	market buy 0.92 GBPUSD sl: 1.65536 (1.67833
/ 1.67838 / 1.67833)					
EQ	0	11:45:42.046	Core 1	2014.04.11 00:00:00	deal #30 buy 0.92 GBPUSD at 1.67838 done
(based on order #30)					
RS	0	11:45:42.046	Core 1	2014.04.11 00:00:00	deal performed [#30 buy 0.92 GBPUSD at
1.67838]					
QE	0	11:45:42.046	Core 1	2014.04.11 00:00:00	order performed buy 0.92 at 1.67838 [#30
buy 0.92 GBPUSD at 1.67838]					
PE	0	11:45:42.046	Core 1	2014.04.11 00:00:00	CTrade::OrderSend: market buy 0.92 GBPUSD
sl: 1.65536 [done at 1.67838]					
IJ	0	11:45:42.046	Core 1	2014.04.11 00:00:00	Execution result: done at 1.67838
OR	0	11:45:42.046	Core 1	2014.04.11 00:00:00	Execution Module initialization complete.
ON	0	11:45:42.046	Core 1	2014.05.21 00:00:00	market sell 0.92 GBPUSD, close #30 (1.68378
/ 1.68388 / 1.68378)					
KE	0	11:45:42.046	Core 1	2014.05.21 00:00:00	deal #31 sell 0.92 GBPUSD at 1.68378 done
(based on order #31)					
EK	0	11:45:42.046	Core 1	2014.05.21 00:00:00	deal performed [#31 sell 0.92 GBPUSD at
1.68378]					
LJ	0	11:45:42.046	Core 1	2014.05.21 00:00:00	order performed sell 0.92 at 1.68378 [#31
sell 0.92 GBPUSD at 1.68378]					
RD	0	11:45:42.046	Core 1	2014.05.21 00:00:00	CTrade::OrderSend: market sell 0.92
position #30 GBPUSD [done at 1.68378]					
CF	0	11:45:42.046	Core 1	2014.05.21 00:00:00	Execution result: done at 1.68378
ML	0	11:45:42.046	Core 1	2014.06.25 00:00:00	buySignal
PJ	0	11:45:42.046	Core 1	2014.06.25 00:00:00	buy_order_approved
FN	0	11:45:42.046	Core 1	2014.06.25 00:00:00	market buy 3.27 GBPUSD sl: 1.69195 (1.69836
/ 1.69843 / 1.69836)					
IM	0	11:45:42.046	Core 1	2014.06.25 00:00:00	deal #32 buy 3.27 GBPUSD at 1.69843 done
(based on order #32)					
DD	0	11:45:42.046	Core 1	2014.06.25 00:00:00	deal performed [#32 buy 3.27 GBPUSD at
1.69843]					
RJ	0	11:45:42.046	Core 1	2014.06.25 00:00:00	order performed buy 3.27 at 1.69843 [#32
buy 3.27 GBPUSD at 1.69843]					
GH	0	11:45:42.046	Core 1	2014.06.25 00:00:00	CTrade::OrderSend: market buy 3.27 GBPUSD
sl: 1.69195 [done at 1.69843]					
FQ	0	11:45:42.046	Core 1	2014.06.25 00:00:00	Execution result: done at 1.69843
NM	0	11:45:42.046	Core 1	2014.06.25 00:00:00	Execution Module initialization complete.
DK	0	11:45:42.046	Core 1	2014.07.24 00:00:00	market sell 3.27 GBPUSD, close #32 (1.70384
/ 1.70397 / 1.70384)					
II	0	11:45:42.046	Core 1	2014.07.24 00:00:00	deal #33 sell 3.27 GBPUSD at 1.70384 done
(based on order #33)					
EF	0	11:45:42.046	Core 1	2014.07.24 00:00:00	deal performed [#33 sell 3.27 GBPUSD at
1.70384]					
EN	0	11:45:42.046	Core 1	2014.07.24 00:00:00	order performed sell 3.27 at 1.70384 [#33
sell 3.27 GBPUSD at 1.70384]					
RO	0	11:45:42.046	Core 1	2014.07.24 00:00:00	CTrade::OrderSend: market sell 3.27
position #32 GBPUSD [done at 1.70384]					
RM	0	11:45:42.046	Core 1	2014.07.24 00:00:00	Execution result: done at 1.70384
MD	0	11:45:48.150	Core 1	2014.10.24 00:00:00	sellSignal
NP	0	11:45:48.150	Core 1	2014.10.24 00:00:00	sell_order_approved
EF	0	11:45:48.150	Core 1	2014.10.24 00:00:00	market sell 2.2 GBPUSD sl: 1.61252 (1.60276
/ 1.60292 / 1.60276)					
DJ	0	11:45:48.150	Core 1	2014.10.24 00:00:00	deal #34 sell 2.2 GBPUSD at 1.60276 done
(based on order #34)					
KD	0	11:45:48.150	Core 1	2014.10.24 00:00:00	deal performed [#34 sell 2.2 GBPUSD at
1.60276]					
PN	0	11:45:48.150	Core 1	2014.10.24 00:00:00	order performed sell 2.2 at 1.60276 [#34
sell 2.2 GBPUSD at 1.60276]					
RL	0	11:45:48.150	Core 1	2014.10.24 00:00:00	CTrade::OrderSend: market sell 2.20 GBPUSD
sl: 1.61252 [done at 1.60276]					
GL	0	11:45:48.150	Core 1	2014.10.24 00:00:00	Execution result: done at 1.60276
LI	0	11:45:48.150	Core 1	2014.10.24 00:00:00	Execution Module initialization complete.
PI	0	11:45:48.150	Core 1	2014.10.27 15:07:19	stop-loss triggered #34 sell 2.2 GBPUSD
1.60276 sl: 1.61252 [#35 buy 2.2 GBPUSD at 1.61252]					
RG	0	11:45:48.150	Core 1	2014.10.27 15:07:19	deal #35 buy 2.2 GBPUSD at 1.61253 done
(based on order #35)					
HM	0	11:45:48.150	Core 1	2014.10.27 15:07:19	deal performed [#35 buy 2.2 GBPUSD at

1.61253]					
DP	0	11:45:48.150	Core 1	2014.10.27 15:07:19	order performed buy 2.2 at 1.61253 [#35 buy
2.2 GBPUSD at 1.61252]					
CP	0	11:45:48.150	Core 1	2014.11.07 00:00:00	sellSignal
HE	0	11:45:48.150	Core 1	2014.11.07 00:00:00	sell_order_approved
FQ	0	11:45:48.150	Core 1	2014.11.07 00:00:00	market sell 1.19 GBPUSD sl: 1.60107
(1.58340 / 1.58350 / 1.58340)					
RE	0	11:45:48.150	Core 1	2014.11.07 00:00:00	deal #36 sell 1.19 GBPUSD at 1.58340 done
(based on order #36)					
EK	0	11:45:48.150	Core 1	2014.11.07 00:00:00	deal performed [#36 sell 1.19 GBPUSD at
1.58340]					
FJ	0	11:45:48.150	Core 1	2014.11.07 00:00:00	order performed sell 1.19 at 1.58340 [#36
sell 1.19 GBPUSD at 1.58340]					
NG	0	11:45:48.150	Core 1	2014.11.07 00:00:00	CTrade::OrderSend: market sell 1.19 GBPUSD
sl: 1.60107 [done at 1.58340]					
NQ	0	11:45:48.150	Core 1	2014.11.07 00:00:00	Execution result: done at 1.58340
LN	0	11:45:48.150	Core 1	2014.11.07 00:00:00	Execution Module initialization complete.
EE	0	11:45:48.150	Core 1	2015.02.09 00:00:00	market buy 1.19 GBPUSD, close #36 (1.52265
/ 1.52299 / 1.52265)					
PF	0	11:45:48.150	Core 1	2015.02.09 00:00:00	deal #37 buy 1.19 GBPUSD at 1.52299 done
(based on order #37)					
JH	0	11:45:48.150	Core 1	2015.02.09 00:00:00	deal performed [#37 buy 1.19 GBPUSD at
1.52299]					
FN	0	11:45:48.150	Core 1	2015.02.09 00:00:00	order performed buy 1.19 at 1.52299 [#37
buy 1.19 GBPUSD at 1.52299]					
GP	0	11:45:48.150	Core 1	2015.02.09 00:00:00	CTrade::OrderSend: market buy 1.19 position
#36 GBPUSD [done at 1.52299]					
LL	0	11:45:48.150	Core 1	2015.02.09 00:00:00	Execution result: done at 1.52299
OD	0	11:45:48.150	Core 1	2015.03.25 00:00:00	sellSignal
PP	0	11:45:48.150	Core 1	2015.03.25 00:00:00	sell_order_approved
LF	0	11:45:48.150	Core 1	2015.03.25 00:00:00	market sell 0.7 GBPUSD sl: 1.51648 (1.48438
/ 1.48454 / 1.48438)					
IJ	0	11:45:48.150	Core 1	2015.03.25 00:00:00	deal #38 sell 0.7 GBPUSD at 1.48438 done
(based on order #38)					
NE	0	11:45:48.150	Core 1	2015.03.25 00:00:00	deal performed [#38 sell 0.7 GBPUSD at
1.48438]					
RO	0	11:45:48.150	Core 1	2015.03.25 00:00:00	order performed sell 0.7 at 1.48438 [#38
sell 0.7 GBPUSD at 1.48438]					
GL	0	11:45:48.150	Core 1	2015.03.25 00:00:00	CTrade::OrderSend: market sell 0.70 GBPUSD
sl: 1.51648 [done at 1.48438]					
GL	0	11:45:48.150	Core 1	2015.03.25 00:00:00	Execution result: done at 1.48438
JH	0	11:45:48.150	Core 1	2015.03.25 00:00:00	Execution Module initialization complete.
NK	0	11:45:48.150	Core 1	2015.04.24 00:01:30	market buy 0.7 GBPUSD, close #38 (1.50584 /
1.50600 / 1.50584)					
KP	0	11:45:48.150	Core 1	2015.04.24 00:01:30	deal #39 buy 0.7 GBPUSD at 1.50600 done
(based on order #39)					
EQ	0	11:45:48.150	Core 1	2015.04.24 00:01:30	deal performed [#39 buy 0.7 GBPUSD at
1.50600]					
OD	0	11:45:48.150	Core 1	2015.04.24 00:01:30	order performed buy 0.7 at 1.50600 [#39 buy
0.7 GBPUSD at 1.50600]					
NF	0	11:45:48.150	Core 1	2015.04.24 00:01:30	CTrade::OrderSend: market buy 0.70 position
#38 GBPUSD [done at 1.50600]					
MK	0	11:45:48.150	Core 1	2015.04.24 00:01:30	Execution result: done at 1.50600
RN	0	11:45:54.253	Core 1	2015.12.28 00:05:00	sellSignal
MJ	0	11:45:54.253	Core 1	2015.12.28 00:05:00	sell_order_approved
MO	0	11:45:54.253	Core 1	2015.12.28 00:05:00	market sell 4.56 GBPUSD sl: 1.49495
(1.49008 / 1.49038 / 1.49008)					
DO	0	11:45:54.253	Core 1	2015.12.28 00:05:00	deal #40 sell 4.56 GBPUSD at 1.49008 done
(based on order #40)					
PM	0	11:45:54.253	Core 1	2015.12.28 00:05:00	deal performed [#40 sell 4.56 GBPUSD at
1.49008]					
PD	0	11:45:54.253	Core 1	2015.12.28 00:05:00	order performed sell 4.56 at 1.49008 [#40
sell 4.56 GBPUSD at 1.49008]					
CI	0	11:45:54.253	Core 1	2015.12.28 00:05:00	CTrade::OrderSend: market sell 4.56 GBPUSD
sl: 1.49495 [done at 1.49008]					
NK	0	11:45:54.253	Core 1	2015.12.28 00:05:00	Execution result: done at 1.49008
IS	0	11:45:54.253	Core 1	2015.12.28 00:05:00	Execution Module initialization complete.
RR	0	11:45:54.253	Core 1	2016.02.05 00:00:00	market buy 4.56 GBPUSD, close #40 (1.45877
/ 1.45914 / 1.45877)					
DM	0	11:45:54.253	Core 1	2016.02.05 00:00:00	deal #41 buy 4.56 GBPUSD at 1.45914 done
(based on order #41)					
MG	0	11:45:54.253	Core 1	2016.02.05 00:00:00	deal performed [#41 buy 4.56 GBPUSD at
1.45914]					
KI	0	11:45:54.253	Core 1	2016.02.05 00:00:00	order performed buy 4.56 at 1.45914 [#41
buy 4.56 GBPUSD at 1.45914]					
LJ	0	11:45:54.253	Core 1	2016.02.05 00:00:00	CTrade::OrderSend: market buy 4.56 position
#40 GBPUSD [done at 1.45914]					
NF	0	11:45:54.253	Core 1	2016.02.05 00:00:00	Execution result: done at 1.45914
GS	0	11:45:54.253	Core 1	2016.02.29 00:00:30	sellSignal
HF	0	11:45:54.253	Core 1	2016.02.29 00:00:30	sell_order_approved
HR	0	11:45:54.253	Core 1	2016.02.29 00:00:30	market sell 0.56 GBPUSD sl: 1.43059
(1.38557 / 1.38610 / 1.38557)					
FR	0	11:45:54.253	Core 1	2016.02.29 00:00:30	deal #42 sell 0.56 GBPUSD at 1.38557 done
(based on order #42)					
LH	0	11:45:54.253	Core 1	2016.02.29 00:00:30	deal performed [#42 sell 0.56 GBPUSD at
1.38557]					
CI	0	11:45:54.253	Core 1	2016.02.29 00:00:30	order performed sell 0.56 at 1.38557 [#42
sell 0.56 GBPUSD at 1.38557]					



KF	0	11:45:54.253	Core 1	2016.02.29 00:00:30	CTrade::OrderSend: market sell 0.56 GBPUSD
sl: 1.43059 [done at 1.38557]					
PF	0	11:45:54.253	Core 1	2016.02.29 00:00:30	Execution result: done at 1.38557
LO	0	11:45:54.253	Core 1	2016.02.29 00:00:30	Execution Module initialization complete.
QG	0	11:45:54.253	Core 1	2016.03.10 17:58:54	stop-loss triggered #42 sell 0.56 GBPUSD
1.38557 sl: 1.43059 [#43 buy 0.56 GBPUSD at 1.43059]					
EM	0	11:45:54.253	Core 1	2016.03.10 17:58:54	deal #43 buy 0.56 GBPUSD at 1.43059 done
(based on order #43)					
FD	0	11:45:54.253	Core 1	2016.03.10 17:58:54	deal performed [#43 buy 0.56 GBPUSD at
1.43059]					
FJ	0	11:45:54.253	Core 1	2016.03.10 17:58:54	order performed buy 0.56 at 1.43059 [#43
buy 0.56 GBPUSD at 1.43059]					
JI	0	11:45:54.253	Core 1	2016.04.13 00:00:30	sellSignal
FI	0	11:45:54.253	Core 1	2016.04.13 00:00:30	Type: Sell   EP: 1.42722   SL: 1.41707
Diff: -0.0101499999999998					
HE	0	11:45:54.253	Core 1	2016.04.13 00:00:30	tradeRejected: SL incompatible with trade
LH	0	11:46:00.356	Core 1	2016.07.15 00:00:00	sellSignal
QN	0	11:46:00.356	Core 1	2016.07.15 00:00:00	Type: Sell   EP: 1.33384   SL: 1.30177
Diff: -0.03207000000000004					
JD	0	11:46:00.356	Core 1	2016.07.15 00:00:00	tradeRejected: SL incompatible with trade
IK	0	11:46:00.356	Core 1	2016.08.15 00:01:30	sellSignal
JN	0	11:46:00.356	Core 1	2016.08.15 00:01:30	sell_order_approved
OJ	0	11:46:00.356	Core 1	2016.08.15 00:01:30	market sell 1.39 GBPUSD sl: 1.30960
(1.29195 / 1.29245 / 1.29195)					
FJ	0	11:46:00.356	Core 1	2016.08.15 00:01:30	deal #44 sell 1.39 GBPUSD at 1.29195 done
(based on order #44)					
RP	0	11:46:00.356	Core 1	2016.08.15 00:01:30	deal performed [#44 sell 1.39 GBPUSD at
1.29195]					
GQ	0	11:46:00.356	Core 1	2016.08.15 00:01:30	order performed sell 1.39 at 1.29195 [#44
sell 1.39 GBPUSD at 1.29195]					
RN	0	11:46:00.356	Core 1	2016.08.15 00:01:30	CTrade::OrderSend: market sell 1.39 GBPUSD
sl: 1.30960 [done at 1.29195]					
HN	0	11:46:00.356	Core 1	2016.08.15 00:01:30	Execution result: done at 1.29195
NG	0	11:46:00.356	Core 1	2016.08.15 00:01:30	Execution Module initialization complete.
OO	0	11:46:00.356	Core 1	2016.08.18 11:30:15	stop-loss triggered #44 sell 1.39 GBPUSD
1.29195 sl: 1.30960 [#45 buy 1.39 GBPUSD at 1.30960]					
HE	0	11:46:00.356	Core 1	2016.08.18 11:30:15	deal #45 buy 1.39 GBPUSD at 1.30960 done
(based on order #45)					
EL	0	11:46:00.356	Core 1	2016.08.18 11:30:15	deal performed [#45 buy 1.39 GBPUSD at
1.30960]					
PR	0	11:46:00.356	Core 1	2016.08.18 11:30:15	order performed buy 1.39 at 1.30960 [#45
buy 1.39 GBPUSD at 1.30960]					
GQ	0	11:46:00.356	Core 1	2016.10.10 00:00:00	sellSignal
HS	0	11:46:00.356	Core 1	2016.10.10 00:00:00	sell_order_approved
HP	0	11:46:00.356	Core 1	2016.10.10 00:00:00	market sell 0.44 GBPUSD sl: 1.29459
(1.23946 / 1.23996 / 1.23946)					
QD	0	11:46:00.356	Core 1	2016.10.10 00:00:00	deal #46 sell 0.44 GBPUSD at 1.23946 done
(based on order #46)					
KJ	0	11:46:00.356	Core 1	2016.10.10 00:00:00	deal performed [#46 sell 0.44 GBPUSD at
1.23946]					
OK	0	11:46:00.356	Core 1	2016.10.10 00:00:00	order performed sell 0.44 at 1.23946 [#46
sell 0.44 GBPUSD at 1.23946]					
HP	0	11:46:00.356	Core 1	2016.10.10 00:00:00	CTrade::OrderSend: market sell 0.44 GBPUSD
sl: 1.29459 [done at 1.23946]					
FP	0	11:46:00.356	Core 1	2016.10.10 00:00:00	Execution result: done at 1.23946
LL	0	11:46:00.356	Core 1	2016.10.10 00:00:00	Execution Module initialization complete.
CD	0	11:46:00.356	Core 1	2016.11.07 00:00:30	market buy 0.44 GBPUSD, close #46 (1.24558
/ 1.24608 / 1.24558)					
KG	0	11:46:00.356	Core 1	2016.11.07 00:00:30	deal #47 buy 0.44 GBPUSD at 1.24608 done
(based on order #47)					
PN	0	11:46:00.356	Core 1	2016.11.07 00:00:30	deal performed [#47 buy 0.44 GBPUSD at
1.24608]					
PP	0	11:46:00.356	Core 1	2016.11.07 00:00:30	order performed buy 0.44 at 1.24608 [#47
buy 0.44 GBPUSD at 1.24608]					
MQ	0	11:46:00.356	Core 1	2016.11.07 00:00:30	CTrade::OrderSend: market buy 0.44 position
#46 GBPUSD [done at 1.24608]					
HO	0	11:46:00.356	Core 1	2016.11.07 00:00:30	Execution result: done at 1.24608
NJ	0	11:46:06.460	Core 1	2017.01.10 00:00:00	sellSignal
QO	0	11:46:06.460	Core 1	2017.01.10 00:00:00	sell_order_approved
KK	0	11:46:06.460	Core 1	2017.01.10 00:00:00	market sell 1.61 GBPUSD sl: 1.23064
(1.21570 / 1.21620 / 1.21570)					
CK	0	11:46:06.460	Core 1	2017.01.10 00:00:00	deal #48 sell 1.61 GBPUSD at 1.21570 done
(based on order #48)					
GQ	0	11:46:06.460	Core 1	2017.01.10 00:00:00	deal performed [#48 sell 1.61 GBPUSD at
1.21570]					
DP	0	11:46:06.460	Core 1	2017.01.10 00:00:00	order performed sell 1.61 at 1.21570 [#48
sell 1.61 GBPUSD at 1.21570]					
JM	0	11:46:06.460	Core 1	2017.01.10 00:00:00	CTrade::OrderSend: market sell 1.61 GBPUSD
sl: 1.23064 [done at 1.21570]					
NO	0	11:46:06.460	Core 1	2017.01.10 00:00:00	Execution result: done at 1.21570
EH	0	11:46:06.460	Core 1	2017.01.10 00:00:00	Execution Module initialization complete.
LN	0	11:46:06.460	Core 1	2017.01.12 10:45:32	stop-loss triggered #48 sell 1.61 GBPUSD
1.21570 sl: 1.23064 [#49 buy 1.61 GBPUSD at 1.23064]					
GD	0	11:46:06.460	Core 1	2017.01.12 10:45:32	deal #49 buy 1.61 GBPUSD at 1.23065 done
(based on order #49)					
RO	0	11:46:06.460	Core 1	2017.01.12 10:45:32	deal performed [#49 buy 1.61 GBPUSD at
1.23065]					
EQ	0	11:46:06.460	Core 1	2017.01.12 10:45:32	order performed buy 1.61 at 1.23065 [#49

buy 1.61 GBPUSD at 1.23064]					
NP 0	11:46:06.460	Core 1	2017.03.16 00:00:00	sellSignal	
OF 0	11:46:06.460	Core 1	2017.03.16 00:00:00	Type: Sell   EP: 1.22862   SL: 1.2195	
Diff: -0.00912000000000017					
HL 0	11:46:06.460	Core 1	2017.03.16 00:00:00	tradeRejected: SL incompatible with trade	
OL 0	11:46:06.460	Core 1	2017.09.22 00:00:00	buySignal	
FJ 0	11:46:06.460	Core 1	2017.09.22 00:00:00	buy_order_approved	
DM 0	11:46:06.460	Core 1	2017.09.22 00:00:00	market buy 1.14 GBPUSD sl: 1.33808 (1.35754	
/ 1.35868 / 1.35754)					
MM 0	11:46:06.460	Core 1	2017.09.22 00:00:00	deal #50 buy 1.14 GBPUSD at 1.35868 done	
(based on order #50)					
DG 0	11:46:06.460	Core 1	2017.09.22 00:00:00	deal performed [#50 buy 1.14 GBPUSD at	
1.35868]					
PI 0	11:46:06.460	Core 1	2017.09.22 00:00:00	order performed buy 1.14 at 1.35868 [#50	
buy 1.14 GBPUSD at 1.35868]					
IH 0	11:46:06.460	Core 1	2017.09.22 00:00:00	CTrade::OrderSend: market buy 1.14 GBPUSD	
sl: 1.33808 [done at 1.35868]					
DQ 0	11:46:06.460	Core 1	2017.09.22 00:00:00	Execution result: done at 1.35868	
LN 0	11:46:06.460	Core 1	2017.09.22 00:00:00	Execution Module initialization complete.	
KD 0	11:46:06.460	Core 1	2017.09.27 09:53:20	stop-loss triggered #50 buy 1.14 GBPUSD	
1.35868 sl: 1.33808 [#51 sell 1.14 GBPUSD					
EE 0	11:46:06.460	Core 1	2017.09.27 09:53:20	deal #51 sell 1.14 GBPUSD at 1.33806 done	
(based on order #51)					
EJ 0	11:46:06.460	Core 1	2017.09.27 09:53:20	deal performed [#51 sell 1.14 GBPUSD at	
1.33806]					
KJ 0	11:46:06.460	Core 1	2017.09.27 09:53:20	order performed sell 1.14 at 1.33806 [#51	
sell 1.14 GBPUSD at 1.33808]					
MQ 0	11:46:06.460	Core 1	2017.12.08 00:00:00	buySignal	
PD 0	11:46:06.460	Core 1	2017.12.08 00:00:00	buy_order_approved	
OP 0	11:46:06.460	Core 1	2017.12.08 00:00:00	market buy 6.98 GBPUSD sl: 1.34442 (1.34703	
/ 1.34772 / 1.34703)					
EP 0	11:46:06.460	Core 1	2017.12.08 00:00:00	deal #52 buy 6.98 GBPUSD at 1.34772 done	
(based on order #52)					
FR 0	11:46:06.460	Core 1	2017.12.08 00:00:00	deal performed [#52 buy 6.98 GBPUSD at	
1.34772]					
LD 0	11:46:06.460	Core 1	2017.12.08 00:00:00	order performed buy 6.98 at 1.34772 [#52	
buy 6.98 GBPUSD at 1.34772]					
NF 0	11:46:06.460	Core 1	2017.12.08 00:00:00	CTrade::OrderSend: market buy 6.98 GBPUSD	
sl: 1.34442 [done at 1.34772]					
MK 0	11:46:06.460	Core 1	2017.12.08 00:00:00	Execution result: done at 1.34772	
RS 0	11:46:06.460	Core 1	2017.12.08 00:00:00	Execution Module initialization complete.	
IS 0	11:46:06.460	Core 1	2017.12.08 14:11:19	stop-loss triggered #52 buy 6.98 GBPUSD	
1.34772 sl: 1.34442 [#53 sell 6.98 GBPUSD					
LN 0	11:46:06.460	Core 1	2017.12.08 14:11:19	deal #53 sell 6.98 GBPUSD at 1.34442 done	
(based on order #53)					
FL 0	11:46:06.460	Core 1	2017.12.08 14:11:19	deal performed [#53 sell 6.98 GBPUSD at	
1.34442]					
JE 0	11:46:06.460	Core 1	2017.12.08 14:11:19	order performed sell 6.98 at 1.34442 [#53	
sell 6.98 GBPUSD at 1.34442]					
PK 0	11:46:12.563	Core 1	2018.01.09 00:00:00	buySignal	
EO 0	11:46:12.563	Core 1	2018.01.09 00:00:00	buy_order_approved	
RK 0	11:46:12.563	Core 1	2018.01.09 00:00:00	market buy 2.73 GBPUSD sl: 1.34882 (1.35675	
/ 1.35709 / 1.35675)					
DG 0	11:46:12.563	Core 1	2018.01.09 00:00:00	deal #54 buy 2.73 GBPUSD at 1.35709 done	
(based on order #54)					
QI 0	11:46:12.563	Core 1	2018.01.09 00:00:00	deal performed [#54 buy 2.73 GBPUSD at	
1.35709]					
KO 0	11:46:12.563	Core 1	2018.01.09 00:00:00	order performed buy 2.73 at 1.35709 [#54	
buy 2.73 GBPUSD at 1.35709]					
KS 0	11:46:12.563	Core 1	2018.01.09 00:00:00	CTrade::OrderSend: market buy 2.73 GBPUSD	
sl: 1.34882 [done at 1.35709]					
KL 0	11:46:12.563	Core 1	2018.01.09 00:00:00	Execution result: done at 1.35709	
KH 0	11:46:12.563	Core 1	2018.01.09 00:00:00	Execution Module initialization complete.	
DN 0	11:46:12.563	Core 1	2018.01.10 12:27:42	stop-loss triggered #54 buy 2.73 GBPUSD	
1.35709 sl: 1.34882 [#55 sell 2.73 GBPUSD					
GK 0	11:46:12.563	Core 1	2018.01.10 12:27:42	deal #55 sell 2.73 GBPUSD at 1.34873 done	
(based on order #55)					
CQ 0	11:46:12.563	Core 1	2018.01.10 12:27:42	deal performed [#55 sell 2.73 GBPUSD at	
1.34873]					
PP 0	11:46:12.563	Core 1	2018.01.10 12:27:42	order performed sell 2.73 at 1.34873 [#55	
sell 2.73 GBPUSD at 1.34882]					
FL 0	11:46:12.563	Core 1	2018.04.06 00:00:00	buySignal	
IK 0	11:46:12.563	Core 1	2018.04.06 00:00:00	Type: Buy   EP: 1.40016   SL: 1.40119	
Diff: -0.0010299999999999864					
RK 0	11:46:12.563	Core 1	2018.04.06 00:00:00	tradeRejected: SL incompatible with trade	
ER 0	11:46:18.666	Core 1	2018.11.07 00:00:00	sellSignal	
JG 0	11:46:18.666	Core 1	2018.11.07 00:00:00	Type: Sell   EP: 1.3095   SL: 1.283   Diff:	
-0.026499999999999997					
MK 0	11:46:18.666	Core 1	2018.11.07 00:00:00	tradeRejected: SL incompatible with trade	
HM 0	11:46:18.666	Core 1	2018.12.05 00:02:00	sellSignal	
GG 0	11:46:18.666	Core 1	2018.12.05 00:02:00	sell_order_approved	
LL 0	11:46:18.666	Core 1	2018.12.05 00:02:00	market sell 1.63 GBPUSD sl: 1.28468	
(1.27111 / 1.27239 / 1.27111)					
PP 0	11:46:18.666	Core 1	2018.12.05 00:02:00	deal #56 sell 1.63 GBPUSD at 1.27111 done	
(based on order #56)					
EN 0	11:46:18.666	Core 1	2018.12.05 00:02:00	deal performed [#56 sell 1.63 GBPUSD at	
1.27111]					
GG 0	11:46:18.666	Core 1	2018.12.05 00:02:00	order performed sell 1.63 at 1.27111 [#56	

sell 1.63 GBPUSD at 1.27111]					
PD 0 11:46:18.666	Core 1	2018.12.05 00:02:00	CTrade::OrderSend: market sell 1.63 GBPUSD		
sl: 1.28468 [done at 1.27111]					
GD 0 11:46:18.666	Core 1	2018.12.05 00:02:00	Execution result: done at 1.27111		
KP 0 11:46:18.666	Core 1	2018.12.05 00:02:00	Execution Module initialization complete.		
DG 0 11:46:18.666	Core 1	2019.01.03 00:01:30	market buy 1.63 GBPUSD, close #56 (1.25985		
/ 1.26101 / 1.25985)					
KH 0 11:46:18.666	Core 1	2019.01.03 00:01:30	deal #57 buy 1.63 GBPUSD at 1.26101 done		
(based on order #57)					
GJ 0 11:46:18.666	Core 1	2019.01.03 00:01:30	deal performed [#57 buy 1.63 GBPUSD at		
1.26101]					
OL 0 11:46:18.666	Core 1	2019.01.03 00:01:30	order performed buy 1.63 at 1.26101 [#57		
buy 1.63 GBPUSD at 1.26101]					
FM 0 11:46:18.666	Core 1	2019.01.03 00:01:30	CTrade::OrderSend: market buy 1.63 position		
#56 GBPUSD [done at 1.26101]					
DS 0 11:46:18.666	Core 1	2019.01.03 00:01:30	Execution result: done at 1.26101		
QF 0 11:46:18.666	Core 1	2019.07.30 00:00:00	sellSignal		
FR 0 11:46:18.666	Core 1	2019.07.30 00:00:00	sell_order_approved		
HG 0 11:46:18.666	Core 1	2019.07.30 00:00:00	market sell 0.84 GBPUSD sl: 1.24811		
(1.22152 / 1.22202 / 1.22152)					
KG 0 11:46:18.666	Core 1	2019.07.30 00:00:00	deal #58 sell 0.84 GBPUSD at 1.22152 done		
(based on order #58)					
PE 0 11:46:18.666	Core 1	2019.07.30 00:00:00	deal performed [#58 sell 0.84 GBPUSD at		
1.22152]					
HL 0 11:46:18.666	Core 1	2019.07.30 00:00:00	order performed sell 0.84 at 1.22152 [#58		
sell 0.84 GBPUSD at 1.22152]					
EQ 0 11:46:18.666	Core 1	2019.07.30 00:00:00	CTrade::OrderSend: market sell 0.84 GBPUSD		
sl: 1.24811 [done at 1.22152]					
LS 0 11:46:18.666	Core 1	2019.07.30 00:00:00	Execution result: done at 1.22152		
RK 0 11:46:18.666	Core 1	2019.07.30 00:00:00	Execution Module initialization complete.		
CK 0 11:46:18.666	Core 1	2019.08.27 00:00:00	market buy 0.84 GBPUSD, close #58 (1.22163		
/ 1.22213 / 1.22163)					
JD 0 11:46:18.666	Core 1	2019.08.27 00:00:00	deal #59 buy 0.84 GBPUSD at 1.22213 done		
(based on order #59)					
PO 0 11:46:18.666	Core 1	2019.08.27 00:00:00	deal performed [#59 buy 0.84 GBPUSD at		
1.22213]					
LQ 0 11:46:18.666	Core 1	2019.08.27 00:00:00	order performed buy 0.84 at 1.22213 [#59		
buy 0.84 GBPUSD at 1.22213]					
IR 0 11:46:18.666	Core 1	2019.08.27 00:00:00	CTrade::OrderSend: market buy 0.84 position		
#58 GBPUSD [done at 1.22213]					
IN 0 11:46:18.666	Core 1	2019.08.27 00:00:00	Execution result: done at 1.22213		
LD 0 11:46:18.666	Core 1	2020.01.17 00:00:00	buySignal		
QQ 0 11:46:18.666	Core 1	2020.01.17 00:00:00	buy_order_approved		
DE 0 11:46:18.666	Core 1	2020.01.17 00:00:00	market buy 5.46 GBPUSD sl: 1.30421 (1.30782		
/ 1.30832 / 1.30782)					
QE 0 11:46:18.666	Core 1	2020.01.17 00:00:00	deal #60 buy 5.46 GBPUSD at 1.30832 done		
(based on order #60)					
QO 0 11:46:18.666	Core 1	2020.01.17 00:00:00	deal performed [#60 buy 5.46 GBPUSD at		
1.30832]					
NQ 0 11:46:18.666	Core 1	2020.01.17 00:00:00	order performed buy 5.46 at 1.30832 [#60		
buy 5.46 GBPUSD at 1.30832]					
IQ 0 11:46:18.666	Core 1	2020.01.17 00:00:00	CTrade::OrderSend: market buy 5.46 GBPUSD		
sl: 1.30421 [done at 1.30832]					
IN 0 11:46:18.666	Core 1	2020.01.17 00:00:00	Execution result: done at 1.30832		
OF 0 11:46:18.666	Core 1	2020.01.17 00:00:00	Execution Module initialization complete.		
EL 0 11:46:18.666	Core 1	2020.01.17 11:00:14	stop-loss triggered #60 buy 5.46 GBPUSD		
1.30832 sl: 1.30421 [#61 sell 5.46 GBPUSD at 1.30421]					
FM 0 11:46:18.666	Core 1	2020.01.17 11:00:14	deal #61 sell 5.46 GBPUSD at 1.30421 done		
(based on order #61)					
KS 0 11:46:18.666	Core 1	2020.01.17 11:00:14	deal performed [#61 sell 5.46 GBPUSD at		
1.30421]					
PR 0 11:46:18.666	Core 1	2020.01.17 11:00:14	order performed sell 5.46 at 1.30421 [#61		
sell 5.46 GBPUSD at 1.30421]					
IN 0 11:46:19.704	Core 1	2020.11.11 00:00:00	buySignal		
LL 0 11:46:19.704	Core 1	2020.11.11 00:00:00	buy_order_approved		
LH 0 11:46:19.704	Core 1	2020.11.11 00:00:00	market buy 0.61 GBPUSD sl: 1.29135 (1.32681		
/ 1.32729 / 1.32681)					
QH 0 11:46:19.704	Core 1	2020.11.11 00:00:00	deal #62 buy 0.61 GBPUSD at 1.32729 done		
(based on order #62)					
GJ 0 11:46:19.704	Core 1	2020.11.11 00:00:00	deal performed [#62 buy 0.61 GBPUSD at		
1.32729]					
IL 0 11:46:19.704	Core 1	2020.11.11 00:00:00	order performed buy 0.61 at 1.32729 [#62		
buy 0.61 GBPUSD at 1.32729]					
QN 0 11:46:19.704	Core 1	2020.11.11 00:00:00	CTrade::OrderSend: market buy 0.61 GBPUSD		
sl: 1.29135 [done at 1.32729]					
IS 0 11:46:19.704	Core 1	2020.11.11 00:00:00	Execution result: done at 1.32729		
FK 0 11:46:19.704	Core 1	2020.11.11 00:00:00	Execution Module initialization complete.		
ND 0 11:46:19.704	Core 1	2020.12.30 23:59:59	position closed due end of test at 1.36236		
[#62 buy 0.61 GBPUSD 1.32729 sl: 1.29135]					
CI 0 11:46:19.704	Core 1	2020.12.30 23:59:59	deal #63 sell 0.61 GBPUSD at 1.36236 done		
(based on order #63)					
PG 0 11:46:19.704	Core 1	2020.12.30 23:59:59	deal performed [#63 sell 0.61 GBPUSD at		
1.36236]					
MN 0 11:46:19.704	Core 1	2020.12.30 23:59:59	order performed sell 0.61 at 1.36236 [#63		
sell 0.61 GBPUSD at 1.36236]					
JN 0 11:46:19.704	Core 1	final balance 112115.97 pips			
JF 0 11:46:19.704	Core 1	GBPUSD,Daily: 250559363 ticks, 4143 bars generated. Environment			
synchronized in 0:00:00.019. Test passed in 0:01:14.428 (including ticks preprocessing 0:00:12.875).					

```
FR      0      11:46:19.704      Core 1  GBPUSD,Daily: total time from login to stop testing 0:01:14.447
(including 0:00:00.019 for history data synchronization)
PO      0      11:46:19.704      Core 1  4875 Mb memory used including 0.47 Mb of history data, 4672 Mb of
tick data
KN      0      11:46:19.704      Core 1  log file
"C:\Users\Otavio\AppData\Roaming\MetaQuotes\Tester\D0E8209F77C8CF37AD8BF550E51FF075\Agent-127.0.0.1-
3000\logs\20210530.log" written
EN      0      11:46:19.881      Core 1  connection closed
```

## ANNEX I – THE AUTOMATED TRADE SYSTEM ALGORITHM

```
#property description "Nova Information Management School"
#property description "Master Program in Statistics and Information Management"
#property description "Otavio Silva Pereira"
#property description "Advisor: Prof. Dr. Jorge Miguel Ventura Bravo"
//
#include <Trade\Trade.mqh>
CTrade trader;
//
input double riskSize = 0.02;
//
double lotSize = 0.0,
       stopLoss = 0.0;
//
input int    fastMA1 = 10, fastMA2 = 20;
input int    midMA   = 50, slowMA1 = 100, slowMA2 = 200;
input int    adxPeriod = 14;
// Handlig File
int fileHandle = 0;

int OnInit()
{
    fileHandle = FileOpen("test01.txt,"
                        FILE_COMMON|FILE_WRITE|FILE_ANSI|FILE_TXT,
                        '\t');
    return(INIT_SUCCEEDED);
}

void OnDeinit(const int reason)
{
    FileClose(fileHandle);
    Print("File Closed");
}

void OnTick()
{
    // Check for new bar
    if(new_candle())
    {
        // Check for open positions
        if(PositionsTotal() == 0)
        {
            // Search for an entry signal
            string alphaSignal = alpha_model();
            // If we have a signal, assess the risk of the trade
            if(alphaSignal != "noSignal")
            {
                Print(alphaSignal);
                string tradeApproval = risk_model(alphaSignal);
                Print(tradeApproval);
                // If execution os approved
                if(tradeApproval == "buy_order_approved" ||
                   tradeApproval == "sell_order_approved")
                {
                    execution_model(tradeApproval);
                }
            }
        }
        else
        {
            position_management();
        }
    }
}
```

```

string alpha_model()
{
    ///--- Reading and handling Indicators data
    int    fastMA1Handle, fastMA2Handle;
    int    midMAHandle, slowMA1Handle, slowMA2Handle;
    int    adxHandle;
    // Get handle for indicators
    fastMA1Handle = iMA(_Symbol, _Period, fastMA1, 0, MODE_SMA, PRICE_CLOSE);
    fastMA2Handle = iMA(_Symbol, _Period, fastMA2, 0, MODE_SMA, PRICE_CLOSE);
    midMAHandle   = iMA(_Symbol, _Period, midMA, 0, MODE_SMA, PRICE_CLOSE);
    slowMA1Handle = iMA(_Symbol, _Period, slowMA1, 0, MODE_SMA, PRICE_CLOSE);
    slowMA2Handle = iMA(_Symbol, _Period, slowMA2, 0, MODE_SMA, PRICE_CLOSE);
    adxHandle     = iADX(_Symbol, _Period, adxPeriod);
    // check for errors
    if((fastMA1Handle == INVALID_HANDLE) ||
        (fastMA2Handle == INVALID_HANDLE) ||
        (midMAHandle == INVALID_HANDLE) ||
        (slowMA1Handle == INVALID_HANDLE) ||
        (slowMA2Handle == INVALID_HANDLE) ||
        (adxHandle == INVALID_HANDLE))
    {
        Alert("Unable to get handle. ERROR ," GetLastError());
        ResetLastError();
    }

    // Copy data and check for errors
    int    bars = 10;
    double fastMA1Array[], fastMA2Array[];
    double midMAArray[], slowMA1Array[], slowMA2Array[];
    double adxArray[], adxDI_plus[], adxDI_minus[];
    //
    if(!CopyBuffer(fastMA1Handle, 0, 0, bars, fastMA1Array) ||
        !CopyBuffer(fastMA2Handle, 0, 0, bars, fastMA2Array) ||
        !CopyBuffer(midMAHandle, 0, 0, bars, midMAArray) ||
        !CopyBuffer(slowMA1Handle, 0, 0, bars, slowMA1Array) ||
        !CopyBuffer(slowMA2Handle, 0, 0, bars, slowMA2Array) ||
        !CopyBuffer(adxHandle, 0, 0, bars, adxArray) ||
        !CopyBuffer(adxHandle, 1, 0, bars, adxDI_plus) ||
        !CopyBuffer(adxHandle, 2, 0, bars, adxDI_minus))
    {
        Alert("Unable to copy data. ERROR ," GetLastError());
        ResetLastError();
    }

    // Sort arrays
    ArraySetAsSeries(fastMA1Array, true);
    ArraySetAsSeries(fastMA2Array, true);
    ArraySetAsSeries(midMAArray, true);
    ArraySetAsSeries(slowMA1Array, true);
    ArraySetAsSeries(slowMA2Array, true);
    ArraySetAsSeries(adxArray, true);
    ArraySetAsSeries(adxDI_plus, true);
    ArraySetAsSeries(adxDI_minus, true);
    // Preparing arrays that will storage the strategy tests
    bool buySignal[];
    ArrayResize(buySignal, bars);
    bool sellSignal[];
    ArrayResize(sellSignal, bars);
    bool slowMAArrayBuySignal[];
    ArrayResize(slowMAArrayBuySignal, bars);
    bool slowMAArraySellSignal[];
    ArrayResize(slowMAArraySellSignal, bars);

    // Fill buy/sell arrays
    for(int i=1; i<=bars-1; i++)
    {
        // Buy signal

```

```

        buySignal[i-1] = (fastMA1Array[i] > fastMA2Array[i] &&
                           fastMA2Array[i] > midMAArray[i] &&
                           midMAArray[i] > slowMA1Array[i] &&
                           slowMA1Array[i] > slowMA2Array[i]);

        // Sell Signal
        sellSignal[i-1] = (fastMA1Array[i] < fastMA2Array[i] &&
                           fastMA2Array[i] < midMAArray[i] &&
                           midMAArray[i] < slowMA1Array[i] &&
                           slowMA1Array[i] < slowMA2Array[i]);
    }

    // If a buy signal is confirmed after 5 candles
    string signal = "";
    if(buySignal[0] == true && buySignal[1] == true &&
        buySignal[2] == true && buySignal[3] == true &&
        buySignal[4] == true && buySignal[5] == false&&
        adxArray[1] >= 20)
    {
        signal = "buySignal";
    }
    // If sell signal is confirmed after 5 candles
    else if(sellSignal[0] == true && sellSignal[1] == true &&
        sellSignal[2] == true && sellSignal[3] == true &&
        sellSignal[4] == true && sellSignal[5] == false&&
        adxArray[1] >= 20)
    {
        signal = "sellSignal";
    }
    else signal = "noSignal";

    // Cleaning Data
    ArrayFree(fastMA1Array);
    ArrayFree(fastMA2Array);
    ArrayFree(midMAArray);
    ArrayFree(slowMA1Array);
    ArrayFree(slowMA2Array);
    ArrayFree(adxArray);
    ArrayFree(adxDI_plus);
    ArrayFree(adxDI_minus);
    // Function will return only one signal per time
    return signal;
}

string risk_model(string &signalReceived)
{
    // Check for open positions
    if(PositionsTotal() > 0) return("tradeRejected: position already open.");

    //--- If signal is a Buy
    if(signalReceived == "buySignal")
    {
        // Setting the Stop-loss
        MqlRates barInfo[];
        CopyRates(_Symbol, _Period, 0, 10, barInfo);
        ArraySetAsSeries(barInfo, true);
        //
        stopLoss = barInfo[5].low;
        double ask = NormalizeDouble(SymbolInfoDouble(_Symbol, SYMBOL_ASK), _Digits);
        // Double check if a stop-loss value was attributed
        if((stopLoss <= 0) || (stopLoss >= ask))
        {
            {
                if(fileHandle != INVALID_HANDLE)
                {
                    write_file("Buy," ask, stopLoss, NormalizeDouble(ask - stopLoss,
                        _Digits));
                }
            }
            else Print("Operation FileOpen failed, error ,\"GetLastError());
        }
    }
}

```

```

        return "tradeRejected: SL incompatible with trade";
    }

    //Calculating the contract size
    double balance = NormalizeDouble(AccountInfoDouble(ACCOUNT_BALANCE),
ACCOUNT_CURRENCY_DIGITS);
    double moneyRisk = balance * riskSize;
    //- Calculating the value of 1 basis point (1 pip)
    double pipValue = 0.0;
    //
    if(_Symbol == "EURUSD" ||
_Symbol == "GBPUSD" ||
_Symbol == "NZDUSD" ||
_Symbol == "AUDUSD") pipValue = 10.0;
    else if(_Symbol == "USDCAD" || _Symbol == "USDCHF") pipValue =
NormalizeDouble(10/ask, _Digits);
    else if(_Symbol == "USDJPY") pipValue = NormalizeDouble((10/ask)*100,
_Digits);
    else
    {
        Print(_Symbol, " is not an tradable Asset. Select a new
asset.");
        return "tradeRejected: invalid asset.";
    }

    // Adjusting base values for setting the Stop-loss
    double SLpips = 0.0;
    //
    if(_Symbol != "USDJPY")
    {
        SLpips = NormalizeDouble((ask - stopLoss) * 10000, 1);
    }
    else SLpips = NormalizeDouble((ask - stopLoss) * 100, 1);

    lotSize = NormalizeDouble(moneyRisk / (SLpips * pipValue), 2);
    ArrayFree(barInfo);
    //
    return "buy_order_approved";
}
//--- If signal is a Sell
else if(signalReceived == "sellSignal")
{
    // Setting the Stop-loss
    MqlRates barInfo[];
    CopyRates(_Symbol, _Period, 0, 10, barInfo);
    ArraySetAsSeries(barInfo, true);
    //
    stopLoss = barInfo[5].high;
    double bid = NormalizeDouble(SymbolInfoDouble(_Symbol, SYMBOL_BID),
_Digits);
    // Double check if a stop-loss value was attributed
    if(stopLoss <= 0 || stopLoss <= bid)
    {
        if(fileHandle != INVALID_HANDLE)
        {
            write_file("Sell," bid, stopLoss, NormalizeDouble(stopLoss - bid,
_Digits));
        }
        else Print("Operation FileOpen failed, error ,\"GetLastError()\");
        return "tradeRejected: SL incompatible with trade";
    }
    //Calculating the contract size
    double balance = NormalizeDouble(AccountInfoDouble(ACCOUNT_BALANCE),
ACCOUNT_CURRENCY_DIGITS);
    double moneyRisk = balance * riskSize;
    //- Calculating the value of 1 basis point (1 pip)
    double pipValue = 0.0;
    if(_Symbol == "EURUSD" ||

```



```

        _Symbol == "GBPUSD" ||
        _Symbol == "NZDUSD" ||
        _Symbol == "AUDUSD") pipValue = 10.0;
    else if(_Symbol == "USDCAD" || _Symbol == "USDCHF") pipValue =
NormalizeDouble(10/bid, _Digits);
        else if(_Symbol == "USDJPY") pipValue =
NormalizeDouble((10/bid)*100, _Digits);
        else
        {
            Print(_Symbol, " is not an tradable Asset. Select a new
asset.");
            return "tradeRejected: invalid asset.";
        }

    // Adjusting base values for setting the Stop-loss
    double SLpips = 0.0;
    if(_Symbol != "USDJPY")
    {
        SLpips = NormalizeDouble((stopLoss - bid) * 10000, 1);
    }
    else SLpips = NormalizeDouble((stopLoss - bid) * 100, 1);

    lotSize = NormalizeDouble(moneyRisk / (SLpips * pipValue), 2);
    ArrayFree(barInfo);
    //
    return "sell_order_approved";
}

    else return "tradeRejected";
}

void execution_model(string execute_trade)
{
    //--- If trade is a BUY
    if(execute_trade == "buy_order_approved")
    {
        trader.Buy(lotSize,
            _Symbol,
            SYMBOL_ASK,
            stopLoss,
            0,
            "sp: " + IntegerToString(SYMBOL_SPREAD));

        // Check trade request status
        Print("Execution result: ," trader.ResultRetcodeDescription());
    }
    //--- Execute a SELL order
    if(execute_trade == "sell_order_approved")
    {
        trader.Sell(lotSize,
            _Symbol,
            SYMBOL_BID,
            stopLoss,
            0,
            "sp: " + IntegerToString(SYMBOL_SPREAD));

        // Check trade request status
        Print("Execution result: ," trader.ResultRetcodeDescription());
    }

    Print("Execution Module initialization complete.");
}

void position_management()
{
    //---Reading and handling Indicators data

```

```

int    MA1Handle, MA2Handle;
// Get handle for indicators
MA1Handle = iMA(_Symbol, _Period, fastMA1, 0, MODE_SMA, PRICE_CLOSE);
MA2Handle = iMA(_Symbol, _Period, fastMA2, 0, MODE_SMA, PRICE_CLOSE);
// check for errors
if((MA1Handle == INVALID_HANDLE)||
   (MA2Handle == INVALID_HANDLE))
{
    Alert("Unable to get handle.  ERROR ," GetLastError());
    ResetLastError();
}

// Copy data and check for errors
int     bars = 3;
double  MA1Array[], MA2Array[];
if(!CopyBuffer(MA1Handle, 0, 0, bars, MA1Array) ||
   !CopyBuffer(MA2Handle, 0, 0, bars, MA2Array))
{
    Alert("Unable to copy data.  ERROR ," GetLastError());
    ResetLastError();
}

// Sort arrays
ArraySetAsSeries(MA1Array, true);
ArraySetAsSeries(MA2Array, true);
// If position is a buy
if(trader.RequestType() == ORDER_TYPE_BUY)
{
    if(MA1Array[1] < MA2Array[1])
    {
        trader.PositionClose(trader.RequestSymbol());
        Print("Execution result: ," trader.ResultRetcodeDescription());
    }
}
// If position is a sell
else if(trader.RequestType() == ORDER_TYPE_SELL)
{
    //--- Test if condition holds
    if(MA1Array[1] > MA2Array[1])
    {
        trader.PositionClose(trader.RequestSymbol());
        Print("Execution result: ," trader.ResultRetcodeDescription());
    }
}
}

void write_file(string type, double EP, double SL, double Diff)
{
    FileWrite(fileHandle,
              type,
              DoubleToString(EP),
              DoubleToString(SL),
              DoubleToString(Diff));
}

bool new_candle()
{
    /*Returns true whenever there is a new candle in the current
    chart time frame. Otherwise, returns false.*/
    MqlRates barInfo[];
    CopyRates(_Symbol, _Period, 0, 1, barInfo);

    // Capture the time of the current bar
    static datetime timeStampLastCheck;
    datetime timeStampCurrentCandle;
    timeStampCurrentCandle = barInfo[0].time;
}

```

```
// Verify the event of a new bar
if(timestampLastCheck != timestampCurrentCandle)
{
    timestampLastCheck = timestampCurrentCandle;
    return true;
}
else return false;
}
```

